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551

ICHNOLOGY OF NEW ENGLAND.

A

REPORT

ON THE

SANDSTONE OF THE CONNECTICUT VALLEY,

ESPECIALLY ITS

FOSSIL FOOTMARKS,

MADE TO THE GOVERNMENT OF THE

Commonwealth of Massachusetts.

BY EDWARD HITCHCOCK,

PROFESSOR IN AMHERST COLLEGE.

"They are fraught with strange meanings, these footprints of the Connecticut."—HUGH MILLER.

BOSTON:

WILLIAM WHITE, PRINTER TO THE STATE.

1858.

Commonwealth of Massachusetts.

[Resolves of 1857—Chapter 83.]

RESOLVE PROVIDING FOR THE PUBLICATION AND DISTRIBUTION OF PROFESSOR HITCHCOCK'S GEOLOGICAL REPORT.

Resolved, That Professor Hitchcock's Geological Report on the Sandstone of the Connecticut Valley, with drawings and maps connected therewith, be printed, under the direction of the committee of the library; that a sufficient number be printed, and one copy furnished to each member of the executive and legislative departments of the government for the present political year, and one copy to each town and city in the Commonwealth.—*Approved by the Governor, May* 29, 1857.

[Resolves of 1858—Chapter 25.]

RESOLVE IN RELATION TO PROFESSOR HITCHCOCK'S GEOLOGICAL REPORT.

Resolved, That one thousand copies of Professor Hitchcock's Geological Report on the Sandstone of the Connecticut Valley, authorized to be printed by chapter eighty-three of the resolves of the year one thousand eight hundred and fifty-seven, be printed at the expense of the Commonwealth, under the direction of the committee on the library; and that, in addition to the distribution already authorized, one hundred copies of said Report be given to Professor Hitchcock, three copies to the state library, and twelve copies to the trustees of the state library, to be used for the purpose of international exchanges.—*Approved by the Governor, March* 26, 1858.

JOINT STANDING COMMITTEE ON THE LIBRARY.

1857.

Messrs. Henry L. Sabin, of Berkshire,
John M. Merrick, of Norfolk, and
John W. Atwood, of Barnstable,
Of the Senate.

Messrs. Charles Hale, of Boston,
Charles Field, of Athol, and
Warren Tyler, of North Brookfield,
Of the House of Representatives.

1858.

Messrs. Charles A. Phelps, of Suffolk,
Charles F. Swift, of Barnstable, and
William T. Davis, of Plymouth,
Of the Senate.

Messrs. Marcus Morton, of Taunton,
Charles Hale, of Boston, and
William A. Saunders, of Cambridge,
Of the House of Representatives.

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REPORT.

MY First Report, made to the government of the State in 1833, on the Geology of Massachusetts, contained no account of those remarkable footmarks in stone in the valley of Connecticut River, which have since awakened so much interest among intelligent men; for they were not discovered till two years later. But in 1841, when I made my Final Report under my second geological commission, I described no less than twenty-seven species of animals as recognized by their tracks, some of them of unheard-of size. The subject, however, has continued to grow in interest and magnitude up to the present time; and every year has added to the number of these track-discovered animals, (*Lithichnozoa*, as I call them,) that once roamed along the shores of the Connecticut, or rather of the estuary that then occupied that valley. In 1848, I made out a full and systematic account of all the animals which had left their tracks on the rocks of the United States, which was published in the Memoirs of the American Academy of Arts and Sciences, and also in a separate volume of one hundred and twenty-eight quarto pages, with twenty-four Plates. Fifty-one species were therein described, all but two of which were disinterred in the Valley of the Connecticut River, mostly in Massachusetts. But the work of discovery has since been going on; and within the last two years the developments have seemed to be more wonderful than ever, so that now I am able to describe no less than one hundred and nineteen species from the Connecticut Valley; and the whole subject seemed never to need revision and new descriptions so much as now.

Other circumstances increase the desirableness of a new and full account of these footmarks. One is, that a collection of them has now been made, embracing nearly every species, to which naturalists can refer, to test the accuracy of drawings and descriptions. This is an object at which I have been aiming for the last twenty years, and at length I have seen it accomplished. So long as we, who described the tracks, could not tell where naturalists would find the specimens which we described, — because they were scattered we knew not whither, — they had no means of testing the accuracy of our drawings and descriptions. But now that I am able to refer to the number of the specimen in a cabinet, which I have described and figured, others can correct my misapprehensions and mistakes. The late Hon. SAMUEL APPLETON, of Boston, left by his will a large sum, to be appropriated

by the trustees on his will, to benevolent and scientific purposes. Those trustees,[1] well known for their liberality towards worthy objects, appropriated $10,000 to the erection of the Appleton Cabinet at Amherst, the upper story of which, one hundred and ten feet long and forty-five wide, has been devoted to the large zoölogical collection, made by the late Prof. C. B. Adams; and the lower story, one hundred feet long and thirty feet wide, to fossil footmarks; and is hence called the *Ichnological Cabinet,* — as yet, I believe, the only cabinet in the world entirely devoted to this object. It is nearly filled with specimens, varying in size from a few inches up to thirty feet in length, and placed in the most advantageous position as to light, for their exhibition. Other benevolent individuals have contributed liberally for the purchase of these specimens, which have cost nearly $5,000. It will not be thought strange that I should strongly desire to describe these specimens, after devoting so much time, money and labor, to collect them. A sample of nearly every species that has been disinterred in the Connecticut Valley will be found in this cabinet. It is my intention, in this Report, to give a description of them all, with references, also, to other permanent cabinets with which I may be acquainted; as, for instance, the fine collections in the Boston Society of Natural History, that made by the late Dr. John C. Warren, and that in Yale College, and the Wesleyan University.[2]

To such an end have my efforts been directed for some years past, doubtful, however, whether Providence would permit me to accomplish it; for so numerous are the illustrations, which a fair exhibition of the subject requires, that the aid of government is indispensable. But though my services in preparing such a Report be gratuitous, — and it gives the results of twenty years' study, — yet, since the facts brought to light, however interesting as matters of scientific information, are generally thought to have little bearing upon the economical interests of the State, can I reasonably expect that the government will incur the expense of their publication? If I had not had experience of the enlarged views of the legislators

[1] Hon. Nathan Appleton, Hon. William Appleton, and N. I. Bowditch, Esq.

[2] This cabinet happens to be connected with Amherst College; but it is really an offering to the cause of science, rather than to any particular institution; and, therefore, I have spoken of it more freely and described it more minutely in this Report, than I should otherwise have done. On this ground I feel constrained to add a list of the names of most of the principal donors, who have enabled me to fill it with specimens by purchase and otherwise; and without which aid I could never have prepared this Report:—

John Tappan, Esq., Boston,	$500 00
Hon. David Sears, Boston,	500 00
Mrs. Abbott Lawrence, Boston,	300 00
Gerard Hallock, Esq., New York,	250 00
Hon. E. P. Prentice, Albany,	150 00
Roswell Field, Esq., Gill,	125 00
John M. Doubleday, Esq., New York,	100 00
William Dickinson, Esq., Worcester,	100 00
Hon. Edward Dickinson, Amherst,	100 00
John Clarke, Esq., Northampton,	100 00
James H. Welles, Esq., New York,	100 00
Hon. Albert W. Porter, Niagara Falls,	50 00
Hon. Jonathan Phillips, Boston,	50 00
Hon. Samuel Williston, Easthampton,	50 00
Hon. John C. Gray, Boston,	25 00
Dr. Nathan Allen, Lowell,	$25 00
William Ropes, Esq., Boston,	25 00
Donations of specimens by the author of this Report, ($2,000); income of the Natural History Fund, ($250); voted by the trustees of the college, ($156); sale of duplicates, ($118); from several other donors, ($100,)	2,624 00
	$5,154 00
From the trustees on the will of Samuel Appleton, for the building,	10,000 00
	$15,154 00

of Massachusetts, and of their disposition to patronize the diffusion of scientific knowledge of various kinds, on the ground that theoretical knowledge often shows an unexpected practical application; — if, I say, I had not had such experience, I should hardly dare cherish such a hope. But as they have already promptly and fully published and illustrated my researches on this subject, I cannot doubt that the same liberal views will lead them to bring out yet other pages of this curious preädamic history of Massachusetts.

I have spoken of this subject as if it had no bearings of consequence upon the economical interests of the State. But in this case there is an unexpected application of this sort, which certainly deserves attention. In describing the footmarks, it has been an important point to determine precisely where the rock, in which they occur, belongs, in the series of geological formations. The Connecticut River sandstone has proved one of the most difficult of rocks to identify with those whose position is settled in Europe and elsewhere. It was early regarded as old as the old red sandstone, or at least the coal formation. Subsequently, a part of it, at least was proved to be as new as the trias, or new red sandstone. But the more recent researches and discoveries of John and W. C. Redfield, of Prof. W. B. Rogers, and Edward Hitchcock, Jr., have produced the conviction that at least the higher beds of this formation, — those containing the footmarks, the fishes, and the ferns, — are as new as the lower part of the jurassic or oolitic series — say the lias. The lower beds may be older, and there seems to be thickness enough to embrace several rocks below the lias.

So long as this rock was regarded as the old red, or the new red, sandstone, the idea of finding workable beds of coal in it was given up. But if it be liassic, as many now regard a part of it, it is identified with the rock in Eastern Virginia, containing beds of bituminous coal of great value; and we may reasonably resume our researches after this valuable substance in the Connecticut Valley, with some hope of success. The facts and reasonings in this case will properly form the preliminary part of this Report.

Were there time, it might be interesting to give a detailed history of the origin and development of the subject of footmarks, denominated *Ichnology*, or the science of tracks. They were doubtless observed much earlier than they were scientifically described. The first published account of fossil tracks was in 1828, by Rev. Dr. Duncan, of Edinburgh, in the Transactions of the Royal Society of Edinburgh. The tracks — those of a tortoise — were found upon the new red sandstone of Scotland. In 1831, Mr. Scrope, an English geologist, published an account of some small crustacean tracks on the forest marble, a variety of oolite. In 1834, a scientific description was given of the footmarks of an animal called the Cheirotherium, on the new red sandstone, or trias, of Hildburghausen, in Germany.

The footmarks in the Valley of Connecticut River were observed much earlier than any of the above dates. So far as I can learn, the first specimen was ploughed up in South Hadley, in 1802, by Pliny Moody, Esq., then a boy, and before he went to college. This specimen, containing a row of five tracks, was purchased by Dr. Dwight, of South

Hadley, and is now in the Appleton Ichnological Cabinet (No. $\frac{16}{2}$). So strikingly did these tracks resemble those of birds, that they were familiarly spoken of as the tracks of "poultry," or of "Noah's Raven."

It was not, however, till the year 1836 that any attempt was made to describe these tracks scientifically. The year previous, some flagging stones were obtained in Montague, for the streets in Greenfield, by Mr. WILLIAM WILSON, who observed impressions upon them which he regarded as tracks of the "turkey tribe."[3] They were observed by the late Dr. JAMES DEANE, who sent casts of them to me, secured them for my cabinet, (*Tridentipes elegans,*) and gave it as his opinion, from their form and succession, that they were made by birds. After visiting all the quarries in my power during the summer, and discovering other and much larger specimens, I ventured to give a scientific description of seven species in 1836, in the American Journal of Science. With a few eminent exceptions,[4] my views were not adopted by scientific men. Yet I continued to explore, and from time to time to describe, new species, till within six years, in which I labored almost alone, as the preceding bibliography will show, they amounted to thirty-two, and a general acquiescence was secured among scientific men in the views that had been advanced. But the bibliography prefixed to this Report will show by whom, and when, and where, these tracks have been described, up to the present time. A glance at this will save the need of a prolix description.

I ought to say, that for several years, I merely gave names to these tracks with reference to their supposed affinities; such as *Ornithichnites*, or stony bird-tracks; *Sauroidichnites*, or like the tracks of Saurians, &c. But more recently, I have named the animals that made the tracks; as *Brontozoum giganteum*, or the huge animal giant: *Polemarchus gigas*, the huge leader in war: *Ancyropus heteroclitus*, or the strange anchor-footed animal, &c., &c. Without some such designations, it is nearly impossible, since they have become so numerous, to describe the different sorts of tracks; and if, as the tracks show, these animals once had a real existence, why is there not as much propriety in giving them names from their tracks, as from bones in other cases?

I trust that I need make no apology for the scientific form which I have given to the following descriptions. I do not believe that the tracks, especially, can be clearly and usefully described in a merely popular way; and yet I have added a *more* popular account of them to the detailed scientific descriptions, for any who have not the time or disposition to study the latter. I have been obliged to coin a few new terms, of which I have added a glossary at the end of the Report. These and the names of all the animals have been derived, after the usual manner, from the Greek and Latin; and they can of course be fully appreciated only by such as are familiar with these languages. After all, there is but little in this Report that cannot readily be understood by intelli-

[3] Dexter Marsh, in a letter to Professor Silliman in 1848, says: "You will recollect that the first specimen of fossil footprints of birds ever brought into public notice in this country, was the slab I discovered among the flagging stone, while laying the flagging stone near my house, which Dr. Deane first described to President Hitchcock as *the footprints of birds.*" From this statement it would seem that Mr. Marsh was the first to notice these impressions. In conversation with Mr. Wilson, I understood him to claim the discovery.—See *American Journal of Science*, Vol. 6, New Series, p. 272.

[4] Professors Silliman, senior, Buckland, Rogers, Emmons, &c.

gent men, — just such men as abound all over Massachusetts. Aware, from personal knowledge, how numerous they are, I did not think it necessary or desirable to endeavor to write as if I were addressing children.

Position on the Scale of Rocks of the Sandstone of the Connecticut Valley.

The geologists who, near the commencement of the present century, first described the sandstone of the Connecticut Valley, (ex. gr. MACLURE, EATON, SILLIMAN, and CLEVELAND,) regarded it as the old red sandstone. In 1823, in my Sketch of the Geology, &c., of the Connecticut, I limited this formation (the old red) to the beds lying below the trap, in Massachusetts, and called those above it the coal formation, some narrow seams of coal having been found in them. In my Report on the Geology of Massachusetts, in 1833, I presented reasons for supposing these upper beds to be the equivalent of the new red sandstone of Europe, while the lower beds were left unnamed. In my Final Report, in 1841, I took essentially the same ground. The strongest argument for this opinion was based upon what is called the heterocercal character of the fishes found in these rocks, — such fish not having been discovered above the new red sandstone. I did not profess to be a good judge of this matter. But Mr. JOHN REDFIELD, of New York, who had shown great skill on this subject, made me the following statement, just before I published my Report, and I of course acquiesced in it. "In my paper," says he, "upon the genus Catopterus, I stated, that in AGASSIZ'S arrangement, it would come under the *homocercal* division of his family lepidoides. This statement was made with a great deal of hesitation; and I now feel disposed to qualify it somewhat. The fact is, that this genus seems to occupy a sort of intermediate position between the two divisions; neither being exactly equilobed, like the homocerci, nor yet having the decided heterocercal character which belongs to those genera which AGASSIZ has placed in that division. But from the strong analogies which, in other respects, it bears to the heterocercal fishes, I am inclined to think it should go among them."—*Final Report on the Geology of Mass.*, p. 440.

Assuming this opinion as to the heterocercal character of these fishes to be correct, and also that of Prof. AGASSIZ, as to the place on the rock series, where such fishes disappear, and the homocerques take their place, and the conclusion could not be avoided, that our sandstone was the trias, or new red. Mr. REDFIELD, however, had, some years earlier, suggested, from the character of the Catopterus, that this sandstone "might have a higher situation in the series than that assigned to it by geologists," because analogous fish had not been found below the lias. From a recent paper by his father, the late WILLIAM C. REDFIELD, Esq., read before the American Association for the Advancement of Science, in August, 1856, it appears that both those gentlemen are of opinion that such is the case, judging alone from the fish. And when we consider the great attention they have given to the subject, and how admirable a collection of fossil fishes they have to judge from, their views cannot but command great respect. Yet, in the language of Sir PHILIP EGERTON, "although this character, derived from the organization of the candal fin, is one of great value and significance in the determination of various fossil genera of

fossil fishes, it is nevertheless necessary, in drawing general conclusions, to be careful not to assign to it more importance than it is strictly entitled to: for we find, by the comparison of several genera, that it is not one of those well defined trenchant characters which can be affirmed to exist or not, as the case may be, but that it is variable in amount, passing from extreme *heterocercy* to absolute *homocercy* by a sliding scale so gradual that it is (at all events in fossil examples) most difficult to define a positive line of demarcation between the two forms." In the Connecticut River fossil fishes, so balanced are these characters that the same observer will place them in different classes at different times; and though, as we have seen, the soundest opinion locates them in the jurassic series, we need other evidence to confirm this conclusion. Such evidence we have in recent discoveries.

Belts of sandstone, analogous in appearance to that of the Connecticut, cross the States of New Jersey, Pennsylvania, Virginia, and North Carolina. One of these belts in Virginia, and another in North Carolina, contains thick beds of bituminous coal. Many years ago, Prof. Wm. B. Rogers made it very probable that the Virginia deposit should be referred to the lower part of the oolitic or jurassic series, like the coal formations of Whitby and Scarborough in Yorkshire, England. For he found in the Virginia rocks specimens of Equisetum, Zamites, and Lycopodites, among the fossil plants, and two species of Posidonomya and two of Cypris among the shells. These fossils have not yet, indeed, been found in the Connecticut River sandstone; but there is such a general resemblance between the Virginia and Connecticut rocks, as to lead Prof. Rogers to regard them as probably identical.—*Proceedings of Boston Society of Natural History*, 1854, p. 14.

Still more decisive as to the jurassic, or rather, perhaps, liassic character of the upper part of the Connecticut River sandstone, are the discoveries of Edward Hitchcock, Jr., M. D., in the strata of Mount Tom, in Easthampton.[5] He has found there a species of Clathropteris, (C. rectiusculus,) a peculiar fern found in Europe, only in the lower part of the lias and upper part of the trias. It occurs not far from the middle of the sandstone of the valley, measuring its perpendicular thickness. It may safely be concluded, therefore, that the rock above this point corresponds to the lias, or lower part of the jurassic series. The importance of this fern in deciding this question, has led me to present two sketches of specimens in the geological cabinet of Amherst College. See Plate V., fig. 1, and Plate VII., fig. 1. The first shows that the fronds of this fern radiated from the top of the stem, like many tropical ferns of the present day,—a fact not shown, I believe, on the European specimens. But our cabinet contains two very distinct examples.

Another discovery by Dr. Hitchcock, Jr., in the same sandstone, is that of a shell or mollusk,—preserved, not petrified,—which, although greatly injured, is allied, apparently, to the rudistae of Lamarck, especially to the sphaerulites and hippurites. This family of shells on the eastern continent seems to be chiefly confined to the chalk

[5] See his description in *American Journal of Science*, Vol. 20, p. 22, New Series.

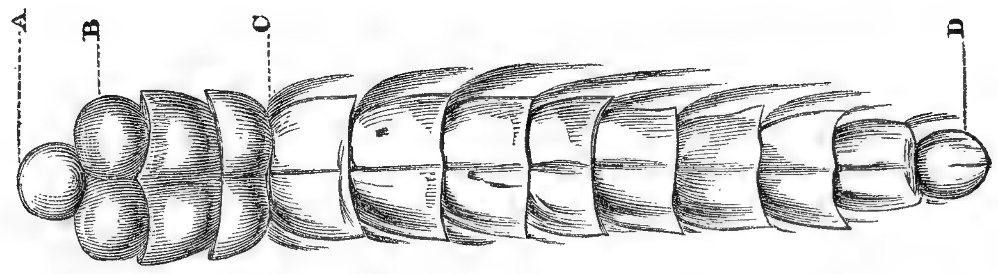
formation; and though the specimen is too much injured to have its genuine character determined, this fact gives plausibility to the opinion that the deposit containing it is newer than the trias. As it is the only shell that has ever been found in the sandstone of this valley, I give a sketch of it. The original is now in Amherst College. See Plate V., fig. 2.

An interesting specimen of some small animal in a fossil state has been found by Roswell Field, Esq., in the shale of Turner's Falls, which deserves notice in this connection. Two sketches of the animal, drawn for me by Mr. F. A. Lydston, of Springfield, are given on Plate VII., figs. 3 and 4: the first of the natural size, and the other a somewhat enlarged view, as seen by the microscope. These show that the creature was articulated, the segments being twelve or thirteen pretty uniformly, corresponding to the larva of an insect; but it seems, also, to have had several legs along the central parts of the body, and these made its crustacean character so probable, that I put it into the hands of Professor J. D. Dana, with the request that he would describe it and name it, since he is so familiar with that class of animals. But just as this sheet was passing through the press, he returned the specimen with the following remarks, which are too valuable to be lost, and which, therefore, I venture to insert in the proof sheet, though I have not time to ask his permission. He says, under date of May 11, 1858: "I have taken up your specimen over and over again, trying to resolve doubts, but still remain undecided; my mind has gradually come to the suspicion, if not belief, that it is a larve of an insect, and not crustacean. I question much whether the depressions on the right side are impressions of true legs; and those on the other side are still less like any thing of the kind; they appear to mark a line or suture in the shell of the segment. I agree with you that your artist has not done justice to the specimen. I have made a rude sketch, merely to indicate some of the characteristics which he has failed to bring out, and which appear to be of special importance. I should regard A to C as corresponding to the head and corselet of the larve, (A the head, B to C the three segments of the corselet,) and C to D as the abdomen. As I cannot make it crustacean, and my knowledge of insects is quite limited, I return the specimen without attempting a description."

"*Postscript.* — The larve was probably a larve of a neuropterous insect, which often has false legs along the abdomen; but if so, it is surprising that there are no legs to the corselet, neuropterous larves having three pairs."

I introduce below the "rude sketch" of Professor Dana, and regret that his modesty prevented him from giving a name and full description, though he has, in fact, stated all that is essential; but as a name is convenient for reference, I venture to propose that of *Mormolucoides articulatus*, (from μοϱμολυκη a larva, and ειδος an appearance; meaning an articulated animal resembling a larva.) But whether it was a real larva I have been led to doubt, if it be true as stated by Milne Edwards, that "the larva condition of many living species typify, or are types of, adult forms or species now extinct." Does not this principle lead to the conclusion that though in appearance a larva, this animal was really an adult insect? But whether a larva or an adult, it increases the probability,

as do the thirteen species of insect tracks to be described, that the rock in which they occur is oolitic; for of the fifteen hundred and fifty-one species of fossil insects described by BRONN, only nine occur below the oolite, and one hundred and nineteen in that formation.



In the geological cabinet of Amherst College is a cone from one of Mr. FIELD'S quarries, so much resembling some described in Europe from the Wealden, that a sketch of it is subjoined: Plate VII., fig. 2.[6] Compare this with fig. 244 of Lyell's Manual of Elementary Geology, fourth edition. I have seen no description of such cones in rocks, below the oolite. Branches of coniferous trees occur in connection with the cone, as is shown in the sketch. They are quite common in the formation.

Other fossil plants and trees of great interest occur in this sandstone. At the Portland quarries in Connecticut, trunks, apparently of tropical trees, are found, entirely converted (*mechanically*, as it seems to me) into sandstone. One in the geological cabinet of Amherst College is thirty inches long and twelve inches in diameter: another, eight and a half feet long, and twenty-four inches in diameter at its base. Similar trunks occur in New Jersey, in what Mr. W. C. REDFIELD calls the *Newark Group*, but of less size; and I have found them, hardly as perfect, however, at Greenfield, in Massachusetts. These trunks have reminded me of those which the European cabinets contain from the oolite of the Isle of Portland. But ours will need more study before any sure conclusions can be drawn from them as to the age of the formation.

I mention only one other fact in corroboration of my conclusion as to the age of this rock. In my Final Report on the Geology of Massachusetts, I have described a fetid and bituminous limestone as one of the varieties of rock interstratified with shales and sandstones in the Connecticut Valley. I have recently traced this limestone with more care, and find it laid open in four places in West Springfield, besides the north bank of Chicopee River, namely, at what is called the Bear's Hole, Paine's Quarry, Meacham's Quarry, and a quarry two miles south of the north line of the town, and two and a half miles west of the river; so that I cannot doubt that it forms a continuous bed, at least ten feet thick, and six miles long. Much of it is a blue compact limestone, much resembling the lias of England. It lies near the base of that series of rocks—sandstones and shales—to which the preceding reasoning applies, having the same easterly dip of about 20°, as the including sandstone and shale, and not far above the trap of Mount Tom. I have not been able, however, to find in it any organic remains which can certainly be identified, although I was tantalized by the description of some of the quarrymen of the perfect shells they used to find in it. But all such statements, in the absence of specimens, must pass for

[6] This also was sketched by Mr. Lydston.

nothing. The situation of this rock, however, and its lithological characters, do certainly make it probable that it may be the equivalent of European lias. It has the position which the lias would have if the preceding reasoning be admitted, and perhaps it is no harder to explain the absence of organic remains from this rock than from the associated sandstone. The valley was probably an estuary, where the fresh water so predominated, that marine animals scarcely lived in it, although the shores were tenanted by numerous races of all sizes, as we shall see shortly, in describing the tracks.

The evidence, then, seems already strong and rapidly accumulating, that at least a part of the sandstone of the Connecticut Valley is as recent as the lias, and possibly some beds even more recent. But does this conclusion and the preceding reasoning apply to all the sandstone of the valley? or only to certain beds? This question I have been trying to solve for several years. In order to do it, I found it necessary to obtain several reliable measured sections across the valley; a work which none of us, who for so long a time have been trying to fix the place of the sandstone, had ever attempted. In 1853, assisted by the class in Amherst College who graduated the next year, I measured a section which crossed the valley through Turner's Falls. In 1854, aided by the class of 1855, I measured a section across Mount Tom; in 1855, another through Springfield; and in 1856, another across Mettawampe, in Sunderland, aided by the class that graduated that year. For the heights I used an aneroid barometer; for the dips, a clinometer, and whenever necessary a tape measure for distances. But in most cases I could avail myself of the State Map, which is so accurate that it may be thus employed.

All these sections I have attached to the present Report (Plate II. and III.). And though from the necessary use of two scales, one for the height and the other for distances, the hills are too steep, in other respects they give a correct view of the position, dip, and thickness of the different strata, errors of measurement excepted. The localities of the footmarks and other important fossils are also given, and I have found these sections eminently instructive, correcting my ideas respecting the character and position of the strata. I found, however, that in order to have all the desirable facts under my eye, it was necessary to construct a geological map of the valley, on which should be marked not only the different rocks, but their strike, the lines of the several sections, and the spots where the most important fossils occur. (See Plate II.) Taking this map and these sections as my guide, I would now make some inferences respecting the rocks, which may correct false impressions, and lead to a true theory as to their character and position.

I ought perhaps to premise, that the sandstone of the Connecticut Valley commences in Northfield, near the New Hampshire line, and extends entirely across Massachusetts and Connecticut, reaching Long Island Sound at New Haven, where it is only a few miles wide. I have extended the map to the Sound, to give a complete view of the formation, although my examinations have been chiefly confined to its northern and central parts. It embraces all the localities of footmarks and other important fossils. The greatest width of this trough is on a line crossing the mouth of Farmington River; though in the latitude of Springfield, where one of our sections was taken, the width is not much less. The entire length is about one hundred and five miles.

Several ranges of trap rock, (greenstone, amygdaloid, and volcanic grit,) traverse this sandstone longitudinally, having for the most part a north-easterly trend, and being generally in the form of interstratified beds or masses. In no place, save near the north end and for a few miles in Amherst, would it be possible to trace a section across the valley, without intersecting a bed of trap: and hence all the sections given herewith, show that rock; the thickest at Mount Tom, and the thinnest on Mettawampe. I have not given all the smaller trap ranges, as traced out with great minuteness and accuracy upon Dr. Percival's Geological Map of Connecticut, but have shown only the principal ranges.

Dip and Strike of the Strata.

The map and sections will give a correct idea of both these particulars. It will be seen that in general the dip is easterly, varying from 5° up to 50°. There are, however, a few exceptions, chiefly near the margins of the sandstone. Thus on the Springfield Section, it will be seen that there is a westerly dip as we approach the hypozoic rocks in the west part of Westfield. Again on the Turner's Falls Section, near the east end, we find somewhat of an anticlinal axis, giving a slight north-westerly dip, though the stratification at this spot is obscure. In Hatfield, also, I have observed a westerly dip extending even across the river to the granite of Mount Warner, as is shown in the Norwottuck Section, Plate III.

The strike in general is north-easterly and south-westerly, ranging, however, between north and south and east and west in particular places. This is particularly the case where the trap ranges curve so as to run in the same direction, as at Mount Holyoke and in Gill. This fact I shall recur to in another connection.

Varieties of Rock on the Sections.

It needs but a cursory examination of the rocks crossed by our sections, to be able to make in them two very distinct groups. All along the west side of the valley, even to Long Island Sound, we find a coarse, thick-bedded sandstone, whose prevailing color is red, but which is sometimes mottled, and near the trap and the hypozoic rocks, sometimes nearly white. It is rare to find interstratified shales or any other rock in this sandstone. The fragments are sometimes very coarse, making in fact a coarse conglomerate, whose layers are from two to four feet thick. The fragments were derived mainly from hypozoic rocks, chiefly from granite.

It will be seen that this sandstone in the northern parts of the basin, — altogether in fact in Massachusetts, — underlies the trap, and is west or north-west of it. Just within the limits of Connecticut, according to Dr. Percival, is a trap range passing through Granby, Simsbury, Canton, and Avon, along the western side of the basin; but in Massachusetts this rock has not extended itself into the lower sandstone beds above described, although I have sometimes observed that slaty sandstones and even shales do extend for a few feet beneath the trap.

Immediately above the trap, that is on its east side, the rocks are quite different; consisting of interstratified red and black shales, volcanic grit, micaceous sandstones, red, gray and white, and compact fetid blue and gray limestone. Still higher up, that is farther

east, we have a recurrence of coarser sandstones, becoming in some places thick-bedded, and resembling those below the trap, but generally distinguishable by the eye. Still farther east, on the very margin of the valley, we find a coarse conglomerate in a few places, of quite peculiar character. It is made up chiefly of fragments of slaty rocks, augillaceous and silicious, such as we find in places farther north, among the metamorphic strata. The fragments are sometimes several feet in diameter, and the stratification of the rock is very obscure. It looks in fact like a consolidated mass of drift.

Now it is in the shales and sandstones lying immediately above the trap, that we find organic remains — the fishes, the tracks, and the plants. Those rocks, then, if our reasoning is correct, are of jurassic or liassic age; but the reasoning does not apply to that thick deposit below the trap; for in those rocks I have never detected any organic relic save fucoids, and perhaps a few trunks of trees, some six or eight inches diameter. This rock, then, may be older than the lias, and it has great thickness. And so the remarkable conglomerate along the eastern margin of the valley, may be a distinct and more recent deposit than the jurassic, since organic remains, with the exception perhaps of one or two species of footmarks, have not been found in it.

We see then that from lithological characters alone, we should be justified in regarding this sandstone as belonging to two and perhaps three geological formations; and since the organic remains supposed to be jurassic scarcely extend below the trap, we may reasonably assign the inferior beds to an older formation; — what one, remains to be determined. Let us see whether other facts derived from the dip and thickness of the strata do not sustain the same view.

Dip of the Beds beneath the Trap the greatest.

If I have rightly represented the dip on the accompanying sections, the lower beds have upon the whole a higher, though not much higher, inclination than those above the trap. It is not so obvious on the Turner's Falls Section as it is upon that crossing Mettawampe, which mountain shows an average dip of only 5° to 10°. The same thing is obvious by comparing the strata west of Mount Tom with those on the east in South Hadley and Granby. How this may be in Connecticut, where a section would cross several trap ranges, I am not prepared to state certainly: but we have the testimony of Dr. Percival, the indefatigable explorer of the trap of this valley, that the same group of rocks as above described exists in Connecticut. The trap, he says, is "bordered on the west by sandstone and overlaid on the east by a band of shale, behind which extends another range of sandstone."—*Geological Report*, p. 409.

This want of conformity between the beds above and below the trap, seems in my judgment to be great enough to give plausibility to the opinion that they belong to two formations.

Thickness of the Strata.

I refer to their perpendicular thickness, supposing them originally horizontal. I have obtained the amount in the usual way, by calling the distance across the upturned edges

the hypothenuse, and the dip one of the angles of a right-angled triangle, whose perpendicular, obtained in the usual way, is the thickness. If, however, the section cross the strata obliquely, it requires the solution of a second triangle before the true thickness is obtained.

Wrought out in this way, I confess that the results give a much greater thickness to the sandstone of this valley than I had anticipated. The numbers stand as follows:—

Whole thickness on the Turner's Falls Section,	11,978 feet.
Do. on the Mettawampe Section,	6,953
Do. on the Mount Tom Section,	12,241
Do. on the Springfield Section,	21,862

The following numbers give the thickness of the several sections above and below the trap:—

On the Turner's Falls Section, above,	4,190 feet.
below,	7,788
On the Mettawampe Section, above,	1,584
below,	5,283
On the Mount Tom Section, above,	8,102
below,	5,115
On the Agawam and Chicopee Sections, above,	11,500
below,	8,128

The length of the several sections is given below:—

1. Turner's Falls Section. Above or east of the trap, deducting 80 rods for disturbed strata at the east end,	1,012 rods.
Below or west of the trap,	1,230
Total,	2,242
2. Mettawampe Section. East of trap,	790
West of do.,	1,170
Total,	1,960
3. On the Mount Tom Section. East of trap,	2,240
West of do.,	1,360
Total,	3,600
4. On the Springfield Section. East of trap,	4,080
West of do., less 480 rods at end,	1,680
Total,	5,760

I omit here the Norwottuck Section, as not throwing much light on the points under consideration.

The Turner's Falls Section and that along Chicopee River, were necessarily measured on more than one line: that is, it was necessary in order to pass over the spots where the rocks were best developed, to turn a little in different directions. This would make the section a little longer than it ought to be, but would produce no important error. The dip or strike usually varied somewhat on these different courses, and it was necessary, as the line of section always crossed the line of strike obliquely, to calculate the perpendicular thickness for each course separately. I first obtained the perpendicular surface thickness by forming a right-angled triangle with the strike and the line of section, and then, using this thickness as the hypothenuse of another right-angled triangle, and the dip as one of the acute angles, I found the net or true thickness sought. That others may know what data I used, they are subjoined:—

LOCALITY.	Course of Section.	Length.	Dip.	Strike.
1. *Turner's Falls Section.*		Rods.		
E. end (less 80 rods) to Horse Race, . . .	N. W. and S. E.	200	28°	W. 10° N.
Horse Race to Lily Pond, ...	W. 15° N.	300	32°	W. 10° N.
Lily Pond to Dr. Field's Footmark Quarry,	Do.	168	34°	N. 70° E.
Field's to Turner's Falls, ...	W. 10° N.	240	37°	N. 70° E.
Falls to Rocky Mt. (Trap), ...	N. 25° W.	104	39°	N. 50° E.
Rocky Mt. to W. end of Section, ...	W. 4° S.	1,230	35°	N. 44° E.
2. *Mettawampe Section.*				
E. of Trap (Mettawampe), ...	E. and W.	790	7°	N. and S.
W. of Trap, ...	E. and W.	1,170	16°	N. and S.
3. *Mt. Tom Section.*				
Rock Rimmon to Mt. Tom, ...	E. and W.	2,240	14°	N. 25° E.
Mt. Tom to S. Hampton Lead Mine, . . .	E. and W.	1,360	15°	N. 25° E.
4. *Chicopee Section.*				
E. end to Indian Orchard, ...	E. and W.	960	20°	N. 45° E.
Indian Orchard to Trap in Westfield, . .	E. and W.	3,120	10°	N. 30° E.
Trap to W. End, less $1\frac{1}{2}$ mile, ...	E. and W.	1,663	20°	N. 30° E.

INFERENCES FROM THE SECTIONS.

A careful examination of the accompanying sections and geological map, with the preceding description, will throw light upon several important points connected with the sandstone of the Connecticut Valley.

1. *Thickness of the Strata.*

As to the actual thickness of the deposit the evidence is certainly not satisfactory. The different sections differ very much on this point, and all of them give such an amount of thickness as far exceeds all our previous notions. Some circumstances might partially

explain these facts. The Turner's Falls Section, for instance, in the part above the trap, runs too nearly on a line coincident with the strike of the strata to give accurate results. It seems in fact to cross what was once the north end of an estuary, nearly in the same direction as the layers of sandstone are deposited; that is, on their strike. The comparatively small thickness on the Mettawampe Section, east of the trap, might be explained by the great amount of erosion to which it has been exposed upon so elevated a spot. But I cannot in this way bring the results into full harmony.

Did we find axes of elevation and subsidence in this sandstone, we could easily explain the great thickness of the whole, by saying that these were reduplications. But the almost uniform easterly dip and the want of correspondence in the rocks on opposite sides of the valley, make such an explanation quite unsatisfactory. In the broader part of the valley, on the Springfield Section, the lithological characters of the rock on the east side of the valley are considerably like those of the rock on the west side, and it is possible they might have been once connected in an arch over the trap. But on the other sections the rocks occupying opposite sides of the valley, are totally unlike.

The opinion has been advanced by several able geologists that the strata of this sandstone, both in New England and New Jersey, were deposited in their present inclined position, and not subsequently elevated. That some part of the dip may have been thus produced, may perhaps, be admitted, as in all other sedimentary deposits. But the following reasons seem to me insuperable against the opinion that these sandstone strata have not been tilted up subsequent to their deposition:—

1. If the strata had been deposited over the floor of the estuary, they must have conformed to the inequalities of the surface, and this, being composed of hypozoic or metamorphic rocks, must have been quite uneven, so that the inclination would have been in all directions, and not so uniformly to the south-east.

2. The materials composing the deposit correspond better with the rocks now found up the valley north of the sandstone, than with those on the east or west sides.

3. Since the hills on both sides of the valley rise sometimes as much as one thousand feet, if the deposition had begun on the west side, as it must have done to have an easterly slope, the same inclination could not have been continued to the very foot of the eastern hills, since these must have been above the ocean, or if beneath, they must have prevented the waves from silting up the valley from that direction. If the sides of the valley were above the waters, as seems almost certain, the materials must have been carried into the estuary by the tributaries from both sides, as well as from the north. And as the estuary must have opened to the south, the silting up must have been from that direction. Probably, however, the current that came from the north, down what is now the Connecticut Valley, had more to do than the ocean with spreading out the materials over the bottom.

4. The prevailing dip of the sandstone in New Jersey (the equivalent doubtless of that along the Connecticut) is opposite to that in Massachusetts and Connecticut. If the ocean deposited the former with a westerly dip, is it credible that on the same coast, a few hundred miles distant, it should place the latter with a contrary dip? It looks rather as if an anticlinal axis, or elevation between them, had been concerned in the tilting up of both.

5. The most perfect and delicate footmarks are found on this sandstone on slopes from 10° to 40°. At Turner's Falls you will see the finest of them where the dip is 40°, running in all directions, and yet showing no marks of distortion as if the animal walked on an inclined surface. Now in the first place, no animal could walk over a slope so high but with difficulty, and certainly not without impressing one part of its foot much deeper than others. I have occasionally seen cases where the heel sunk twice as deep as the toes: but this would require a dip of only some 10° to 15°, whereas at the Falls and at Mr. Field's quarries, where the dip is nearly 35°, the imprints are so evenly made as to indicate that the animals moved over a horizontal surface.

I see no way of escaping from the force of this last argument to show that this sandstone has experienced an upheaval since its deposition. I am confident that no one, who has paid attention to the tracks of living or extinct animals, will doubt that this fact decides the question, certainly as to those places where it exists. And when to this we add the force of the other arguments adduced, it seems fair to conclude that original deposition on a slope will not account for the dip of our sandstone. Suppose we should even allow that one-half of the dip was thus produced. There would still remain a thickness of strata sufficient to embrace not merely the oolite, the trias and the permian, (in all scarcely five thousand feet,) but still more.

Another and more plausible mode of explaining the great thickness of the strata on these sections, is by supposing faults to exist in the sandstone, so that the strata have been measured more than once. I should be quite willing to admit this solution of the difficulty, had I been able to discover the evidence of such faults and dislocations of the strata. But I have found none of any consequence. We can hardly doubt that along the line of the trap ranges such faults exist; and, indeed, in my Final Report on the Geology of Massachusetts, I presented some facts leading to such a conclusion. But I have never found any evidence of consequence that the same strata are repeated along any of the sections. Certainly the extensive formation below the trap has very little resemblance to that above, and the one could not have been produced from the other. Besides, if there be a fault along the ridges of greenstone through which they were protruded to the surface, it could not have affected the strata below the trap. And this gives us a deposit on all the sections over five thousand feet thick; the rock being quite uniform in character throughout; while above the trap, all will admit thickness enough of rock for all the liassic and oolitic series of Europe.

2. *Mode in which the Sandstone has been elevated so as to have an easterly dip.*

Knowing that trap rock had an igneous origin and was of course erupted from the earth's interior, and finding so many ridges of it running through the Connecticut Valley, it was natural to suppose that the associated sandstone was tilted up by this agency. Such has been the opinion of able geologists. Such I judge was Dr. Percival's impression. For he says: "The sandstone ridges are arranged generally obviously in conformity with the arrangement of the trap system, and apparently owe their elevation to the same force which has elevated the trap."—*Report on the Geology of Connecticut*, p. 408.

I acknowledge that an examination of the sections appended has compelled me to abandon this opinion, to which I had once been inclined. We find proof, indeed, that in some places the trap has been intruded among the sandstone strata in such a manner as to change somewhat the dip and strike for a limited space, as at the mouth of Miller's River, at the east end of Norwottuck and near New Haven. But the great body of the sandstone seems not to have been affected essentially by the trap, as the following arguments appear to me to show:—

1. The amount of trap is too small to have accomplished such a work.

One does not get a full conviction of the small relative quantity of this rock till he inspects a section. The largest body of trap in the valley is Mount Tom. Yet imagine this to be placed beneath a horizontal deposit of sandstone eleven miles wide, (which is the length of the Mount Tom Section,) and to be forced up through it. For how small a part of the distance would it have tilted the strata! Still more inadequate appears the narrower ridge of rocky mountain on the Turner's Falls Section, which is seven miles long. Yet more insufficient does it appear on the Mettawampe Section, and least of all, probably, on the Springfield Section, which is eighteen miles long.

2. The protrusion of trap along the lines where its ridges now exist, could not have produced an easterly dip through the whole formation, but rather an anticlinal dip. In receding from the axis, both east and west, the dip would be less and less, until it entirely died out. It is not possible that such an agency should give a general easterly dip, unless it were exerted along the very western edge of the formation: and we have seen that in Massachusetts no trap occurs in the thick-bedded sandstone occupying the western half of the valley, although we do find it in that position as we pass southerly into Connecticut. True, we find in a few places along the western margin of the valley, a westerly dip; but it never reaches within a mile or two of the trap, and seems to have originated in some other agency. The conclusion, then, seems very reasonable that the elevation of the sandstone was not due to the trap, though in a few places I think there is evidence that the trap has modified the dip and strike for a limited extent; as I shall attempt to show in speaking of the manner in which the trap has been intercalated.

3. It is impossible that the trap should have had any thing to do with the tilting up of the strata that lie below or to the west of itself.

It lies upon their upturned faces, and therefore, its only effect would be to press them down. Yet if we judge from the sections, we have strata some thousands of feet occupying this subjacent position. Nay; the dip below the trap is decidedly larger than above, as the preceding statements will show. I cannot conceive by what ingenious reasoning any can reconcile this fact with the opinion that all the sandstone was tilted up by the trap. It ought surely to put us upon searching for some other cause for its elevation.

Justice to myself, perhaps, requires me to state that in my Final Report on the Geology of Massachusetts in 1841, I referred it to the same agency that raised the hypozoic or metamorphic rocks, forming the sides of the valley. I am still of the same opinion. It is well known that these older rocks, extending from Canada to Alabama, have experienced a lateral or plicating movement by a force from the south-east. These movements, most active during

the silurian period, doubtless continued in diminished waves, as late as the triassic and jurassic periods. The fact that the strata run in the same direction as the Appalachian ridges, while the valley itself has a direction more nearly north and south, is a strong proof that the elevation of the strata had a connection with this wide movement. I think myself that the strata below the trap were somewhat raised up before the eruption of the trap, and that the entire formation experienced a second tilting process after the deposition of the strata above the trap.

I really do not see how any force acting beneath the strata could have raised them into the position they now occupy, across so wide a valley. But if the sides of the valley were crowded nearer together, the inevitable result would be to throw up the edges of the strata more or less according to the amount of lateral movement. We might expect, also, especially if the elevating force did not act exactly at right angles to the direction of the valley, that along the somewhat irregular sides there would be places where the strata, subjected to unusual pressure, might be made to dip westerly, and be bent and distorted, — as we find they are at the east end of the Turner's Falls Section and the west end of the Springfield Section, and in one or two other places. In short, this mode of elevation by the great Appalachian movements, meets and harmonizes all the facts; while that by the protrusion of trap, scarcely agrees with any of them.

3. *Mode in which the Trap Rock has been intercalated among the Sandstone.*

Two theories have been defended on this subject. One is that the trap was intruded from beneath among the sandstone strata after their deposition and consolidation. The other is, that after the lower beds of sandstone were deposited, and perhaps somewhat tilted up, the trap was thrown up from beneath and spread over the upper part of the strata, the mass rising in many places above the waters which then covered most of the valley. Subsequently the work of depositing the sandstone was resumed, and that which lies above the trap was laid down. New outbursts of the trap, however, occurred at subsequent periods; but less in quantity, as if the eruptive force were dying out. Hence we almost always find a second but smaller interstratified mass of trap to the east or above the main one.

It will help us to arrive at a just conclusion on this point to state the relative situation of the trap and sandstone. The sections show it at a glance, so far as Massachusetts is concerned. For here the trap is always interposed between the strata of sandstone. Even where the trap range seems to cross the sandstone, I find that in fact it is interposed in successive beds as shown on the Norwottuck Section, which crosses the east end of what was formerly called the Holyoke range. Indeed, I have never met with a real dyke of trap in Massachusetts. But in Connecticut, especially the southern part, they are not uncommon, as is shown by Dr. Percival, and as was shown by myself as long ago as 1823, in the sixth volume of the American Journal of Science. Indeed, although Mount Tom is the largest mass of trap in the valley, yet Connecticut appears to me to be rather the focal region of that rock. I do not doubt that deep in the earth, some of the same dykes which appear at the surface in that State, do extend northward into Massachusetts, and that through them the trap ranges were protruded. But the outbursting masses seem to have spread

over the faces of the sandstone strata, instead of bursting through them, and rarely if ever do we even find overlying masses of the trap — I mean on the edges of the sandstone.

My own opinion is decidedly in favor of the second of the foregoing theories as to the orgin of our trap, and for the following reasons: —

1. The dip of the sandstone below the trap is upon the whole larger than above it. This is shown on the sections and in the table we have presented a few pages back. On the Turner's Falls Section, indeed, there is a slight increase of dip as we approach the trap on the east side and the intrusion of the trap may be the cause. Yet if the strata have been tilted up by a force acting from south-east to north-west, such is the position of the trap and the sandstone at that spot, that this lateral force would give a higher dip to the strata at Turner's Falls than farther east, because the former, from the north-east trend here taken by the trap, would be as it were wedged in more than farther east. The same is true on the Norwottuck Section, and these are the only two places where I find the high dip of the strata to favor at all the theory of mechanical intrusion after the consolidation of the sandstone. Almost everywhere there is the want of evidence of any such mechanical violence. Every thing appears as if the trap formed successive layers deposited along with the sandstone, and not subsequently introduced; except that the masses of trap, as at Mount Tom, are swelled out in the middle and abruptly terminated at the ends. In such cases the sandstone above mantles around the trap, conforming to its inequalities, not as if that rock were forced through it, but as if the sandstone were deposited upon the trap subsequent to its consolidation.

Now if the trap had been forced in mechanically among the strata after their consolidation, it must everywhere have tilted up the sandstone at a higher angle than its dip farther east. It cannot, therefore, have been thus intruded. I think, however, that in some places there may have been an upward movement of the trap since its first intercalation. It would be strange if the successive outbursts, which we know to have occurred, should not have crowded farther upward in some places that which had been already introduced.

2. The existence of successive beds of trap interstratified with the sandstone, and especially of volcanic grit, or trap conglomerate, after the production of the main body, makes it very probable that the sandstone above the trap was not deposited till this latter rock had assumed essentially its present position.

The trap conglomerate is almost as distinctly stratified as is the sandstone, and always lies above the trap, and usually separated from it by beds of sandstone. It is mainly composed of comminuted trap, sometimes vesicular, embracing fragments of the same along with pebbles of other rocks, and passes sometimes into regular trap. It seems to have been the joint work of fire and water. If a slight outburst of melted matter were to be spread over the bottom of an estuary, already partially occupied by sand and gravel, such a sort of rock might be produced; or more usually, perhaps, the waves wore off both the trap and the sandstone, and redeposited them. Indeed, I cannot see how else but by the action of ice and water the fragments of trap in this rock could have been broken off and rounded. So that the stronger probability is, that a large part of the volcanic grit and conglomerate were thus produced, rather than by the flowing of melted trap over a surface of sand and gravel.

I have formerly expressed the opinion that this tufaceous conglomerate might have resulted from some precursory outbursts of trap earlier than the production of the principal masses, such as Holyoke and Tom for example. But a measurement of the appended sections has led me to change that opinion, and to suppose that the principal masses were the first to be erupted; for the smaller masses lie above these with sandstone interposed; and, therefore, must have been of subsequent date. Indeed, every appearance indicates that the sandstone was deposited quietly upon the great masses of trap, which have not been since moved to any great extent. And the occurrence of the trap conglomerate confirms the opinion that the principal or lowest masses of trap must have furnished the materials for its production. It shows too, that the erosion of the trap and the gathering together of the fragments to form a new rock, must have been a work requiring much time and could not possibly have been paroxysmal.

The same thing is taught by the interstratification of the beds of genuine trap, only a little in advance of the main bed, and below the trap conglomerate, separated from both by shales usually. For how absurd to suppose that these advanced trap beds, also, were thrust in between the layers of shale after their consolidation, and yet have left no trace of such intrusion, although it could not have been done without tearing those shales to pieces, — certainly it must have given the layers above the trap a much higher tilt than those below.

3. The position of the fossil footmarks in this valley makes it probable that the sandstone was deposited upon the trap, instead of being rent asunder and tilted by its intrusion.

The map and sections will show that these footmarks, with only three or four exceptions, lie above the trap, and at no great distance. Now the occurrence of rain drops with the footmarks shows that the surface on which both were made was above the waters. There can, indeed, be no doubt that the tracks were impressed by animals walking along a muddy shore, generally out of the water, but sometimes wading a little into it. And these impressions are continued on successive layers to the thickness of several rods, almost without interruption, as on the banks of Connecticut River in the south part of Northampton. It seems certain in such cases that the animals walked over the mud as the layers were deposited. Thus we are made certain that there was a shore just above the trap while the successive strata were in a course of deposition. The probability is that the eruption of the trap produced an island ridge in the waters, and that the heat of the cooling rock made it a favorite resort for animals, and rapidly dried, and therefore preserved their tracks in such perfection as we find nowhere else on the globe.

There are two exceptions to the position of the footmarks as above described. One is on Holyoke, where a few have been found immediately below the columnar trap. The spot is two hundred and fifty-three feet above Connecticut River. See its position on the Norwottuck Section.[7] Now it is clear that this place must have been above the waters before the eruption of the trap: and since the junction of the sandstone and trap on Holyoke and Tom is about as high as the spot where the footmarks occur, there may have been a shore

[7] This section does not cross the place where the track occurs, which is several miles to the south-west, a little south of the path leading to the summit of Holyoke. But its position in relation to the trap is precisely as given on the section, and therefore I have introduced it.

of sandstone of considerable extent produced by the general Appalachian movement already referred to. If such were the case then the formation of the trap would only bring the ridge farther out of the water, and give a larger amount of land to form a rendezvous for various tribes of animals. The other case is at the south end of Mount Tom, where, at Bassett's Quarry, at least two species of footmarks occur, along with the clathropteris and other plants, immediately beneath the trap; as may be seen on the Mount Tom Section. This spot is a little higher than the footmark locality on Holyoke.

4. *Position of the important Fossils of the Sandstone.*

I mean the footmarks, fishes, reptiles, and all others, whose character throws any light upon the age or contents of the sandstone. These are all shown upon the map and sections; and it appears that all of them, with the exceptions named above, occur on the upper side of the trap, and in the lower part of that division of the formation that consists of shales and fissile sandstones. That seems to have been a period peculiarly favorable, either to the development of life, or to the preservation of its remains: — the latter probably is the most plausible supposition. My own opinion is, that the thick-bedded sandstone below the trap was deposited in much deeper water, and therefore, we find in it scarcely any thing but fucoids. But near the close of the period of its formation, a tilting process commenced, which brought up a portion of the rock to the surface, and gave a footing for animals and plants, and then sprang up the gigantic clathropteris and animals *(Brontozoum giganteum, validum and Sillimanium)* began to tread the shores. Next the trap was erupted, which extended the area of land, and afforded a congenial resort for animals of all sizes, from the huge Brontozoum giganteum and Otozoum Moodii, down to almost microscopic myriapods and insects. (Plates XXIX. and XXX.) The fauna of that period, as shown by tracks alone, must have been unusually full, as we shall see when we come to describe the footmarks, embracing more than one hundred species. Then, in the upper beds, in Springfield and Windsor, we have the bones of two species of reptiles. The higher beds of this series, however, afford but few organic relics, and it may be that the disturbed state of the waters necessary to produce the very coarse conglomerates of Mettawampe, might have been inconsistent with much abundance of life, at least in the waters.

5. *Conclusions as to the Age and Equivalency of the Connecticut River Sandstone.*

American geologists are getting to be more and more of the opinion that so different was the state of things on this continent from those in Europe when our fossiliferous strata were deposited, especially those above the coal, that a close identification with those of the eastern continent is impossible; and that they will be compelled to make out an independent series for the western world. Yet if the whole globe has been gradually cooling down, and similar causes have been operating all over its surface, as most geologists believe, we should expect at least a general correspondence between rocks formed at the same period; though their fossil contents might be specifically unlike. Hence we ought to do our best to make out equivalency, before attempting to establish an independent system. Great difficulties certainly attend such an effort in regard to our Connecticut River sandstone.

But there is progress as new discoveries come to light, and from the discussions on the preceding pages, I must regard the following conclusions as having a good deal of plausibility.

1. There is a belt of sandstone lying in Massachusetts, immediately above the trap, which is the equivalent of the oolitic or jurassic series of Europe, especially the lias.

I need not repeat the arguments in support of this position; but almost every new fossil strengthens it, and it seems to me that we may regard this belt of rock as a settled horizon, by which we may judge of the rocks above and below.

2. This belt of sandstone is the equivalent of the lower jurassic sandstone of Eastern Virginia and North Carolina, containing very valuable beds of bituminous coal.

Professor W. B. Rogers has proved the jurassic character of the Virginia coal field, and shown its identity with that of North Carolina. The preceding arguments prove the belt of sandstone above the trap in the Connecticut Valley to be of the same, or nearly the same age, although the fossils in the Connecticut Valley, with the exception of the fishes, are so unlike in the Connecticut Valley, and at the South, that they cannot be directly compared. W. C. Redfield, however, thinks the fishes to be the same in Massachusetts and Connecticut, as in Virginia and North Carolina, in which last named State they have been recently found by Professor E. Emmons.

3. Hence workable beds of coal may be found in the Valley of the Connecticut.

Thin seams of this valuable substance, it is well known, have been found there in years past, and borings for it have been attempted in a few places. In nearly every locality the coal occurs in the liassic belt of rocks above described. In Berlin, Connecticut, Dr. Percival has described highly bituminous coal "in trap," where it comes in contact with shales that rest at a short distance upon a more westerly ridge of trap. It could not, of course, have been produced in trap, which was certainly once melted, though possibly it may have been sublimed by intense heat from the sandstone below, as I have suggested in respect to a very pure bituminous coal found in *veins* in West Springfield. (See Final Report on Geology of Massachusetts, p. 140.) In other localities the coal is anthracite, and occurs only in thin seams; probably the largest quantity yet found was at Berlin, where Dr. Percival speaks of masses weighing "two or three pounds." (American Journal of Science, Vol. 5, p. 44.)

For several years past, however, I have had but little hope that coal in workable quantity could be found in this valley, because the rock was not of the right kind; but if we have here a prolongation, as it were, of the Virginia jurassic sandstone, containing there most valuable beds of coal, the presumption certainly is that the same may occur here. It is by no means certain that they will, for coal is not always present where a coal formation is; but the facts in the case encourage us to keep our eyes open to every indication of this mineral. In my Final Report I have pointed out a few spots in the valley where the indications are most favorable, and to that work (p. 138,) I would again refer.

I think this discussion will satisfy any intelligent man how important it is that every relic of an animal or plant found in our rocks should be carefully preserved; for

it may enable the geologist to determine the true character of a formation, and thus to decide whether there is a probability or not that valuable minerals may be found in it. Oh, how trying it has been to learn how many relics of this sort have been dug out of the sandstone of this valley, and are entirely lost, because thought to be of no value! when probably they might have decided the true character of the sandstone, and shown whether we may hope to find coal, gypsum, or rock salt in it.

4. The strata of this sandstone below the jurassic belt are thick enough to embrace the triassic and permian groups, and perhaps even more.

All the sections measured give a mile in thickness below the trap; call it only half this thickness, and it exceeds that of the trias and permian of Europe combined. I do not assert that these rocks exist here, but only that there seems to be room for them, and future discoveries may identify them. Though no limestone occurs in these lower beds in Massachusetts, yet the sandstones present in some places a striking resemblance, in their lithological characters, to those of the trias and permian of Europe. But as yet scarcely any but fucoidal remains have been found in this lower sandstone, and these plants are too obscure in their characters to identify different and distant formations.

5. The upper part of this sandstone formation, — the coarse conglomerates of Mettawampe, — may be found to have a place in the rock series higher than the jurassic.

No organic remains occur in this conglomerate; but as it is made up of mica slate, talcous slate, argillaceous slate, and quartz rock, all, perhaps, metamorphic, and comparatively recent, with only occasional nodules of gneiss and granite; as it occupies the uppermost place in the series, and its strata are almost horizontal, though its stratification is obscure, a presumption may be awakened that it is a formation of posterior date to that of the subjacent sandstones and shales, whose fineness and regularity indicate a deposition in a period of great quiet. But the huge boulders, three and four feet in diameter, found in the conglomerate, seem to indicate a period of disturbance, such, perhaps, as followed the deposition of the oolite in Europe. The chalk, it is well known, succeeds to the oolite; this conglomerate would, indeed, be a singular equivalent of chalk; yet it is not destitute of calcareous matter, as the small stalactites found in its fissures and caverns testify.

I throw out these suggestions as to this conglomerate, not because I have any settled opinion concerning its geological position, but only to awaken attention to it. I think we may reasonably presume it to be as new as the oolite; perhaps it is newer.

Just as this Report was going to press, an abstract of the Geological Report of North Carolina, by my friend, Professor E. Emmons, has appeared in the American Journal of Science, from which it appears that he has adduced strong arguments to show that the sandstone of that State, which I have supposed to be probably the equivalent of that in the Connecticut Valley, and in Virginia, belongs to the upper new red, and to the permian of Europe. I do not see that any of the arguments which he uses to prove this, conflict with those I have employed to show that there is a jurassic or liassic belt running through our sandstone, which evidence I must leave to stand or fall on its own merits. As to the rock below this belt, I have suggested that it may embrace both the trias and the

permian, so that my views may not, after all, conflict with those of Professor EMMONS; for to prove that these rocks exist in North Carolina would not disprove the existence of a jurassic formation above them in Massachusetts.

FOOTMARKS.

The preceding discussions form an almost essential preliminary to the main object of this Report; viz. a description of the fossil footmarks so prolific and various in the Connecticut Valley; for unless we can settle with some degree of probability the place of the sandstone on the geological scale, the history of the footmarks is comparatively unimportant. It is their supposed great antiquity that gives them their chief interest. We have formerly supposed them to occur in the trias, or new red sandstone; but the reasoning above presented makes it more probable that the rock is the equivalent of the lower part (probably the lias) of the jurassic or oolitic series. This raises them only a little on the scale, but it brings the facts rather more in accordance with geological disclosures in other parts of the world, and strengthens our convictions of the truth of the great principles of paleontology.

The grounds on which I propose to name and describe the animals that made the fossil footmarks, are derived from comparative anatomy and zoology. These sciences show a mathematically exact relation to exist, not only between different classes and families of animals, but between different parts of the same animals. Each class, family and species, are formed on a particular type or model; and when the naturalist has ascertained the typical characters, he can refer an unknown specimen to its true place on the zoological scale; so if he find only one part of an animal, the foot, for instance, he can most frequently infer the form and general character of the other parts. It is like an equation in algebra; having the known quantities on one side, we can ascertain the unknown upon the other side. The result may sometimes be ambiguous, as it is in quadratic equations; but the relations between the different parts in animals is probably as certain as between quantities in mathematics.

Now the feet of animals furnish, probably, the best means, unless it be the teeth, of judging of the class, family, and species to which it belongs. Who, for instance, would confound the human foot with that of any other animal? Again, compare the feet of mammiferous animals (quadrupeds) with those of birds; or of birds with those of reptiles; or, among the mammalia, the feet of the ruminantia with those of the carnivora or marsupialia; or, among birds, the feet of the grallæ with those of the passeres or palmipedes; or the feet of the kangaroo, or platypus, with those of the tiger or the hog; or those of the Struthis rhea (South American ostrich) with those of the eagle or albatross. Some of the orders of birds are, in fact, distinguished by characters drawn from their feet; and the same might be done, to a considerable extent, in other classes of animals. When we attempt in the same way to distinguish different genera and species, the clue will sometimes fail us, just because we cannot get a knowledge of it; but this will only lead to making too few instead of too many genera and species, and this error is more venial with naturalists than its opposite.

With such facts before him, it is no wonder that we find Cuvier, the great founder of comparative anatomy, saying, that "any one who observes merely the print of a cloven hoof, may conclude that it has been left by a ruminant animal, and regard the conclusion as equally certain with any other in physics or morals. Consequently this single footmark clearly indicates to the observer the forms of the teeth, of all the leg bones, thighs, shoulders, and of the trunk of the body of the animal which left the mark. It is much surer than all the marks of Zadig" — referring to an eastern story.

Why then, in view of such facts, should we not name and describe an unknown animal, though nothing but its tracks remain from which to judge of its nature? For in truth a track in relief (as all are on the under side of the sandstone layers,) scarcely differs from the foot petrified; and if Cuvier's principle be true, it will generally give us a tolerably correct idea of the other parts of the body. Why can we not construct the whole animal from this petrified foot, as well as the anatomist can from a single bone belonging to some other part of the frame? Yet of very many of the animals named and described by paleontologists, only a single bone or fragment of a bone has been discovered. I was surprised, therefore, to find, when a few years ago I first attempted to name and describe the animals that made the tracks, that some naturalists thought the evidence was quite insufficient to justify such a course: nay, thought it useless to name the animals at all. And yet I had not only the authority of Cuvier above quoted, but the example of Professor KAUP in naming the Cheirotherium, and of Professor RICHARD OWEN, in naming the Testudo Duncani. But since the time when I followed such high authorities, so many have done the same (ex. gr. Sir WILLIAM JARDINE, in his splendid "Ichnology of Anandale," and ISAAC LEE in his still more splendid "Fossil Footmarks of the Red Sandstone of Pottsville,") that I do not judge it necessary to go into a long argument, as I then did, to justify me in naming and attempting to restore these early inhabitants of the Connecticut Valley.

It is important, however, that I should go into a detailed account of those parts and characters of the feet of animals, which being different in different families and species and yet constant in the same species, may be relied on for generic and specific descriptions, Yet I hope it will not be forgotten, that on this subject I have had to find out my way alone, almost unaided by previous researches. This fact ought, I think, to secure me some indulgence of criticism, especially when the peculiar difficulties of the subject are taken into the account.

Characters that are constant and distinctive in the Feet of Animals, and in their mode of progression.

1. *Number of Feet.* — In almost all classes this number is definite. In the mammalia it is always two, or four: two in man, and perhaps also in the quadrumana, though their anterior extremities are more properly feet than hands. In birds it is always two; in reptiles it is usually four, sometimes only two, which are merely rudimentary, as in the siren, and sometimes none at all, as in serpents. In insects it is six; in crustaceans six to ten, including the feet-jaws; in arachnida, or spiders, eight; in the myriapoda unlimited, but usually large, as in the centipede, and in the annelida none, save the spines or setæ at the joints.

2. *Relative size and character of the Feet.* — Corresponding feet are almost always alike; that is, such as are on opposite sides of an animal, as the two feet of bipeds, and the two hind feet, or the two fore feet of quadrupeds. But not so when we compare one set of feet with another, in quadrupeds and other animals with more than two feet. The hind feet of quadrupeds are often larger, but rarely smaller[8] than the fore feet, and of quite different shape, as those of the kangaroo. The number of toes, also, often differs either apparently or really; thus the kangaroo has five toes on the fore feet, but on the hind feet they are in the adult state usually consolidated into three, with the exception of the claws. In batrachians and lizards the hind and fore feet rarely correspond, and are often totally unlike; so it is with the different sets of feet on insects, arachnida, and crustaceans, but less so in the myriapods.

3. *Modes of progression with the different Classes of Animals.* — At first thought it would seem to be an easy matter to determine what kind of impressions would be made by different sorts of animals upon mud, as they move forward, and that bipeds might always be distinguished from quadrupeds, and from those with more numerous feet; but, in fact, this is one of the most difficult points in ichnology. The following statements are the results to which my own observations upon recent and fossil footmarks have conducted me: —

Bipeds leave tracks nearly equi-distant, except when slackening or accelerating their pace; nearly in a right line if the animal's legs are long, but deviating more or less from the line of direction to the right and left, according as the leg is longer or shorter, and the body wide or narrow.

The more the tracks deviate from the line of direction, which I call the median line, and the greater the angle which the axis of the foot makes with that line outward, the stronger the presumption that the animal was a quadruped.

The right and left foot can be distinguished by the following marks: —

In the pachydactylous, or thick toed animals, by the number of phalangeal impressions, which are usually different on the different toes.

In four-toed animals, one of whose toes points backward, by the hind toe, which is always on the inside of the foot.

I used to suppose that in bipeds, more frequently than in quadrupeds, the toes turn inwards towards the line of direction; but the exceptions are too numerous to allow of any rule to be deduced from this circumstance.

The inner front toe in bipeds is usually shortest; yet it is sometimes difficult to determine which is the shortest in fossil impressions.

But even when the above characters show a regular alternation of the right and left foot, we sometimes find that the animal was a quadruped, as will be shown in speaking of the tracks of that class.

The simplest and plainest case of the footmarks of a quadruped, is where the animal leaves two rows of tracks, some distance apart; the impressions in each row showing

[8] The mole is a striking exception.

two tracks close together, or even interfering, and then a much longer interval before another two are reached, as is shown on Plate VII., figs. 7 and 16. This is a common mode of progression with quadrupeds, and is well exhibited usually in the tracks of a horse; but some animals, the cat and dog for instance, frequently bring the hind foot so exactly into the place vacated by the fore one, that often it is necessary to examine quite a row of tracks before discovering the double impression.

The character of the foot in such cases will often distinguish the tracks of a quadruped from those of a biped. If there be a solid or divided hoof, or if the foot have five, or even four toes, the presumption is very strong that the animal is a quadruped. If, however, some of the feet have only three toes, it will not do to infer that they were not made by a quadruped; for some such, both living and fossil, had only three, either on the hind or fore feet. The kangaroo, for instance, although originally possessed of five toes behind and before, exhibits in an adult state only three on the hind foot, in consequence of a consolidation of the toes. So some living lizards (see sketch of a small salamander, Plate VI., fig. 9,) have only three toes on the front foot. We have the same facts in the foot marks. The hind foot of the Anomocpus major, for instance, has only three toes on the hind foot, although we are sure it was a quadruped. (Plate VIII.) We have reason to think, also, that some of those species making tridactyle impressions were quadrupeds, (ex. gr., Plate XVII., figs. 7 and 8,) and we know that the Rhynchosaurus, whose bones were found in England, and described by Professor OWEN and Mr. WARD, was a lizard with trydactyle fore feet.

Some quadrupeds walk so nearly in a right line, that they do not make two rows of tracks distinctly, as the dog, the cat, and the fox. If in such a case they bring up the hind foot exactly into the place vacated by the fore one, it may be very difficult to distinguish their tracks from those of bipeds; moreover, some, the dog for instance, have a singular habit (it may result from some injury in the foot) of holding up one foot for a considerable distance, and advancing by a sort of hop upon three legs. Such a habit, of course, increases the difficulty of distinguishing the impressions.

Some quadrupeds that make two distinct and wide apart rows of tracks, would not necessarily place them so as to make intervals of unequal length between them; such an animal, for instance, as the banded proteus, (*Menobranchus lateralis*,) could not bring up the hind foot half way to the place left by the fore foot, and therefore the tracks might be arranged as in Plate VI., fig. 7. These sketches were obtained from observing a live specimen of the animal, as it stood at the bottom of the water, and after death placing it in the same position. This is one of that tribe of animals, rare at present, that seem to me to come nearer to some that made the fossil footmarks than any other, in the form and position of its feet, the number of toes, &c.; but a tortoise might present an example of footmarks of analogous character.

The greatest difficulty in deciding upon the quadrupedal character of fossil footmarks, results from the fact that the fore feet, in many species of the animals that made them, were much smaller than the hind feet, and left so slight an impression that in most cases it was obliterated. Hence it often requires numerous specimens to find a single

impression of the fore feet. In such cases the large angle made by the axis of the foot with the line of direction in the footmark, or the great distance to the right and left of the line of direction of the alternate tracks, or the outward curvature of the toes, may lead one to be almost certain that the animal was a quadruped, and thus lead to the detection, at length, of the fore foot. Several such discoveries I have made since my last publication on this subject, the most remarkable of which was in the case of Otozoum Moodii.

The character of the heel in such cases, and the position and direction of the hind toe, often furnish a strong presumption as to the nature of the animal; for with few exceptions, bipeds (that is birds) do not leave the impression of a very long or large heel, and the hind toe in living birds usually forms a prolongation of the outer toe inwards. If, then, the hind toe proceeds at right angles to the axis of the heel, or far back upon it, if the heel be long or large, we may feel a good degree of confidence that the animal was a quadruped, even though as yet we have found only the marks of two feet.

Those who have not thought upon the subject may, perhaps, find it hard to believe that the fore and hind feet on some animals point in opposite directions, so that it might be difficult to determine from the track which is the hind and which the fore foot; but a glance at the sketch of Salamandra Beechyi, Plate VI., fig. 12, will show how it might be. In such case the hind foot is usually the largest, and the toes longest, and often, too, it has five toes behind, and only four on the front foot.

There are other difficulties in distinguishing quadrupedal tracks in the rocks, arising from the fact that some of the toes often failed to leave an impression; but the details on this point will be given when I come to speak of the number of toes characteristic of different tribes.

As to the modes in which animals with more than four feet advance, so recently have their tracks been discovered in the rocks, that those of living species have scarcely been studied at all. If, as is very probable, the tracks discovered by Sir William Logan, in Canada, and described by Professor Richard Owen, be those of crustaceans, we have at least one interesting example of the mode in which one tribe of this class, namely, those which, like the Macrura and Xiphosura, move directly forward, advanced. Three or four pairs of limbs seem to have been employed, each bifurcated, with a fifth smaller pair to make the supplementary impressions, each having "the hard, sub-obtuse, and sub-angular terminations of a crustaceous ambulatory limb, such as may be seen in the blunted legs of a large Palinurus or Bingus." The normal position of the impression in such a case is by twos and threes, arranged on a line placed at an angle of about 45° with the line of direction, with the marks of a tail between the right and left sets; but in other cases there is scarcely no order in the arrangement of the tracks.

There is another tribe of crustaceans, called the brachyurous, which in walking move sideways, whose tracks must be quite peculiar and perplexing.

So far as an inspection of six-footed insects, or eight-footed arachnidans, will enable us to judge, we should suppose it possible that as many rows of tracks, some of them parallel to the line of direction, and some of them divergent, might be made; but the probability would be still greater that some of the feet would make a deeper impression

than others, so that a less number of rows of tracks would remain than the animal had legs. The wonder is, that animals so small and light should leave any impression that would be converted into rock; but, that all their six or eight feet should do it, would be most marvellous. In the insect tracks that I have seen on the rocks, it is, perhaps, most common to see only three or four rows, but in several instances they are six. (See Plates XXIX. and XXX.) No fossil tracks of arachnidans have been found.

The myriapods would leave but two rows of tracks, making a large angle with the line of direction; the tracks, however, would be numerous. These tracks, as well as those of insects, would be simply right lines; for the lateral hairs and terminal branches on some of them would not probably remain upon rock. The myriapod tracks I distinguish from those of insects simply by the former having only two rows, while the latter have more. It is strange to me that so many should remain with any distinctness, as we see on Plates XXVIII. and XXXI.; but the specimen Plate LV., fig. 4, on clay, from Hadley, has still more delicate impressions, and that this was made by a myriapod it seems hardly possible to doubt.

As to the annelids, we should not expect to find any thing but a single or a double groove, since they have no feet, unless the small setae or hairs at their joints be thus regarded; but these are not used for locomotion, I believe, unless it be under ground.

To aid in giving an idea of the feet and mode of walking of some living animals, somewhat analogous to the fossil footmarks, I have given, on Plates VI. and VII., outlines of the feet and tracks of several species.

Plate VI.

Fig. 3. Foot of the Palapteryx of New Zealand.
4 and 5. Foot of the Iguana.
6. Foot of the coot.
7. Tracks of the banded proteus. (Menobranchus lateralis.)
8. Tracks of Fringilla, or snow bird.
9. Lizard, with three toes on the fore foot.
10. Sketch of Phyllurus Cuvieri.
11. Sketch of Dactylura capensis, a frog with claws upon its toes.
12. Sketch of Salamandra Beechyi, the hind toes pointing in a direction opposite to that of the front ones.
13. Foot of the Ornithorhynchus.

Plate VII.

Fig. 5. Tracks of a mink?
6. " " muskrat.
7. " " dog.
8. " " partridge.
9. " " mouse.
10. " " tortoise.
11. " " goose.

Plate VII.—(Continued.)

Fig. 12. Tracks of a domestic hen.
13. " " peahen.
14. " " turkey.
15. " " quail.
16. " " wharf rat.
17. " " crow.
18. Foot of a mink?
19. " " muskrat.
20. " " plover.
21. " " Tringa.
22. " of Tetrao lagopus.
23. " " Hypsiprimnus pencillatum.
24. " " Perameles obesula.
25. " " Lacerta lemniscata.
26. " " Lacerta agilis.
27. " " the stork.
28. " " Ardea herodias.
29. " " Ardea pavonina.
30. " " New Holland ostrich.
31. " " Ardea cœrulea.
32. " " Charadius Wilsonius.
33. Larva tracks. Larva of an insect common on the maple tree in the autumn.

4. *Relations between the Tracks and the form of the Animal's Body.* — Judging from living animals, we may be confident that when we find tracks, either bipedal or quadrupedal, nearly in a straight line, and wide apart, the animal's body was raised high, and was comparatively light and slender; but the shorter the steps, and the farther they are to the right and left of the median line, the thicker and more clumsy we may presume the body to have been. Compare, for instance, the light, delicate bodies of the grallae with those of the goose and the duck, or of the dog and fox with the woodchuck or the mole.

If the axis of the track is placed almost at right angles to the median line, and the rows are far apart, we may infer an animal not only with a thick body, but only a little raised from the ground. If a tail dragged behind, the body may have had considerable length; but if there are several traces occasionally seen between the rows of tracks, we may presume they were made by a carapace, like that of a tortoise. If there are no traces of tail or carapace, and the tracks are not very distinct, but at right angles almost to the median line, and no rain drops are present, we may suspect the impressions to have been made by an animal partly buoyed up in the water, and pressing lightly on the bottom. (See Plate XLIX., fig. 4.)

5. *Relation between the Tracks, and the length and position of the Legs.* — It needs no special argument to show that long strides require long legs, and short steps short legs. So, too, it is equally clear that if the axis of the track makes a large angle with the median line, the leg must proceed from the side of the animal; and if the metacarpal or metatarsal bones made an impression on the rock, it shows sprawling feet. Sometimes we find the same bones behind, sloping upwards, showing that the leg had that position, and consequently the tibia must have had a slope in the opposite direction, and the femur in the same direction, so as to form a very crooked leg.

The most important application of these principles is to certain quadrupedal tracks, found fossil, that are so nearly in a right line as to forbid the idea that they could have been made by any lizard or batrachian, like those now living, and to awaken the inquiry whether (since their fore and hind feet are unequal) they may not have been marsupial. This question I shall consider in the proper place.

6. *Webbed Feet.* — When a web made an impression deep enough to be manifest, it is certainly an important fact, and characterizes certain animals; but I have been surprised to find how seldom distinct evidence of such an appendage appears in the fossil tracks. Yet, on examining the tracks of such animals as the goose and the duck, I find that it is only in a favorable state of the mud that any distinct trace of the web is left. We have at length found some fossil specimens with webbed feet, as the Otozoum and the Uphepus. (Plates XVII., fig. 2, and XXII.)

I have still some doubt in respect to the former; but if there be no mistake, the web extended even beyond the pellets of the toes; while in the Uphepus it probably reached to the extremity of the claws on the lateral toes, but not on the middle toe.

7. *Winged Toes and Claws.* — Some living birds, as the Fulica (coot) and Tringa (snipe), have a membrane running along the toes, and scalloped, so as sometimes to conform to

the number of phalanges, as in the Tringa. In the Colymbus (grebe) this membrane extends to the tip of the toes, though not scalloped. I have supposed that we have analogous cases in the fossil footmarks, so far as the claws are concerned, and have made the fact the foundation of a generic distinction. The phalangeal impressions of this genus (Amblonyx) are so analogous to those whose rounded under side seems to preclude the idea of a winged margin, that I cannot presume upon the existence of wings on the phalanges; but, so difficult is it on any other supposition to explain the form of the claws, that I have concluded to retain the genus, especially as I find examples of these winged claws on the same slab with others that are acuminate.

8. *Pachydactylous and Leptodactylous Feet.* — The literal meaning of pachydactylous is thick-toed, and of leptodactylous, narrow-toed. The tracks of the former show moulds or casts of toes wide in proportion to their length, with distinct claws and phalangeal impressions. The leptodactylous feet and tracks are narrow and rarely show plalanges or claws, although generally pointed. Sometimes they are very narrow.

Since the feet of the animals that made the tracks sometimes sunk from an inch to three or four inches into the mud, and we find in a few cases that as the animal withdrew its feet the mud collapsed, so as to make the track narrower at the top than at the bottom, the inquiry arises whether such was not the origin of all the leptodactylous tracks. But this would make all the tracks pachydactylous, which would be contrary to the analogies of existing nature. Among living animals we find just the distinction of feet which I have made in the tracks, viz.: the thick-toed and the narrow-toed. Compare, for instance, the feet of the Struthronidae (the ostrich tribe) with the Ardea or Charadrius: or those of the thick-toed frogs with the iguana. Again we find the narrow and the broad fossil tracks on the same surface, and often it is clear that the animal did not sink at all into the mud, except so far as to make a simple impression.

I think, then, that this distinction is a natural and important one. I know that some tracks are intermediate as to width, and I have not, therefore, made this character the basis of classification, although I once did so. But still it is a distinction that exists in most cases, and is quite important in settling the character of the animals.

9. *Number of Toes.* — This among living animals is a constant and important character, and none the less so probably among the extinct races. The following statement shows the number of toes in the several classes and tribes of living animals.

The number in the mammalia varies from three to five: for even the horse has two appendages beneath the skin of the foot, that makes him no exception. The tapir has four in front and three behind; the rhinoceros has three; the hippopotamus four; the ruminants, ox, &c. two, and two rudimentary; the hyena, and some carnivora, four to each foot; dogs, five behind and four in front; ateles, or spider monkeys, the same.

There is a two-toed sloth and a three-toed sloth, as well as ant eater.

The kangaroo has originally five toes before and behind: but the latter usually become consolidated into three, except that the claws often remain distinct.

The bats, most of the quadrumana and carnivora, bears, civets, and cats, have five before and behind.

In birds we find from two (in the African ostrich) to four. When two, or three, they all point forward, and sometimes when there are four, as in the Tringa, Colymbus, &c.; but usually in this case one points backward, generally on a prolongation backward of the outer front toe; but sometimes, as in the crow, directly behind, like a heel. And sometimes, as in the scansores or climbers, two are directed forward and two backward.

Crocodiles have five in front and four behind; lizards have usually five before and behind, but sometimes three in front.

Among batrachians, frogs and salamanders have four in front and five behind. The siren has four in front and no feet behind. The proteans have three in front and two behind. In the amphiuma the toes are two in some species and three in others. The menobranchus has four small feet. Land tortoises have four toes behind and five before; fresh water tortoises five before and behind.

The free extremities of insects are sometimes armed with two small toes or claws.

Those of crustaceans are usually single, but they sometimes bifurcate, and some of their limbs have a still larger number of lamelliform appendages.

It requires a good deal of care not to be deceived in respect to the actual number of toes in the fossil footmarks. In living animals, especially birds, the hind toe is usually articulated to the tarso-metatarsus above its extremity, so that it often does not reach the ground, or only its extremity does so. And in the fossil footmarks we sometimes find that only the extreme point made an impression; and that, too, only upon the uppermost layer. While the other toes seem to have depressed the layers of mud an inch or two, or more, in depth in some instances, this one reaches only a slight distance downward. Hence we often obtain specimens, apparently very perfect, in which the hind toe is wanting, when in fact it was present on a higher layer. The same liability to deception occurs in some cases when a short toe was attached to some part of a long heel, as it is in some reptiles. It might be only very rarely that it made an impression, save, perhaps, upon the highest layer.

The changes that take place in tracks in a vertical direction, that is, on successive layers of rock, is one of the most fruitful sources of error as to their true character and the number of toes. I have specimens which show the same track, or parts of it, to the depth of four or five inches; and if such a rock be split in different places, it will often show considerable diversity of forms, and yet it may be that all of them shall be quite distinct; so that, if we have only one layer, it is very difficult often to determine whether it was the identical layer on which the animal trod, or one above or below it. In following a track downward, the hind toe, if it had one, usually first disappears; next the heel, then the lateral toes, while the central one sinks the deepest.

In the Plates annexed, I have given several examples of the changes that occur in tracks in a vertical direction, as they are shown upon successive layers of the rock. Plate XIX., figs. 3, 4, and 5, exhibits a track probably of both the fore and hind foot of Plectropterna minitans, on three successive layers, the whole about two inches in

thickness. Figs. 6, 7, 8, and 9, of the same Plate, show the Triænopus leptodactylus on successive layers, but little more than an inch in thickness. In this case the heel shows itself on the inferior layers, but not on the upper one; probably because the mud collapsed after the foot was withdrawn. In the case of the Apatichnus circumagens, (to the description of which I refer,) the heel, as well as trace of a tail, show themselves on the upper surface, but not an inch below, although there the toes are much more distinct. Plate XIX., figs. 10, 11, and 12, exhibit a track of the hind and fore foot of Plectropterna minitans, so united as to seem to be only one track as seen on the upper layer. But their appearance on different layers, makes it almost certain that they are tracks of the hind and fore foot. The more detailed account of these specimens will be reserved until I come to describe the Plectropterna minitans.

The above statements show us the great difficulty, in some cases, of ascertaining the precise layer of rock on which the animal walked. Where the surface was considerably firm, and quite different materials were drifted in afterwards, this question is not difficult to decide; for then the impression extends very little distance up or down, and is quite imperfect, save on one layer, which of course will be regarded as the one originally trodden upon; and fortunately such is the case with the larger proportion of tracks. But where the materials were very soft, it would seem as if the toes sank considerably into the mud, and were withdrawn without much disturbance; though afterwards the edges of the impression thus made approached each other. In no other way can we explain the extreme narrowness of some of the tracks found on the fine red shale of Wethersfield especially. There, as already remarked, the impressions sometimes extend through from one to four inches, and the layers are bent down so as to be almost perpendicular to the surface. Some have thought that in this case we could determine how far the animal sank, by finding where the depressed laminæ of rock cease to be fractured, and come out in regular curves, when they are split asunder. As far, indeed, as the foot did sink, we should not expect the rock would cleave in curved layers. But may not the narrow toes have bent down the layers so much, beneath where they reached, that they (*i. e.* the layers) would meet in an angle at the bottom so acute, that, when the rock was split open, they would break across rather than cleave asunder? In such a case we should infer by this rule that the animal sank deeper than was the fact; and, indeed, I have sometimes found the print of a lateral toe, for instance, showing a perfectly continuous lamination across its depression, while that of the middle toe, nearly an inch deeper, was fractured. Although, therefore, this principle does help us somewhat in determining the layer on which the animal trod, it cannot be implicitly followed. If possible, we should obtain dissections of the track from top to bottom; and by combining the impressions on the successive layers, we shall probably get an accurate view of the entire foot. On one layer we may find a mere digitigrade, and on another or higher layer a plantigrade impression; on one a heel, or a fourth toe, and on another, neither. I think it true in general, however, that the layer on which the animal trod was usually nearer the bottom of the impressions than the top.

Those who have seen the manner in which successive layers of copper, deposited in the process of electro-metallurgy, retain the slightest markings upon the surface, will readily conceive that fine mud would do the same; less perfectly, indeed, but still so as to preserve the form of a track through many successive layers. On this ground, they will not be surprised that several layers often present the track with so nearly equal distinctness, that the one originally impressed can no more be distinguished than the film of copper that was first deposited can be from those superimposed afterwards.

The most perfect specimen of this kind which I have ever met, is what I call the *Fossil Volume* (No. $\frac{21}{4}$) shown on Plate LII., fig. 6. Here we have five leaves or layers of micaceous sandstone, the whole five inches thick, each showing two footmarks; and though so thick, the impressions are nearly alike on all the layers. This specimen was got out by the late DEXTER MARSH, and the chance of ever obtaining another so perfect is very small.

The oblique direction in which the impressions often pass through successive layers, while their distinctness is not impaired, is a matter of surprise, and not so easily explained. Sometimes the track seems to advance, and sometimes to recede, and sometimes to move laterally on the successive layers, taking the lowest one as the fixed basis. This might proceed in part from the oblique direction in which the foot of the animal was exerted; as when running, for instance, the impression would be made so as to reach the successive layers farther and farther backward, because the legs incline forward; or suppose the surface to be inclined, and the animal going directly or obliquely up or down upon it. It is clear that the impression, in such case, would be communicated to the successive layers obliquely to the surface, so as to produce the phenomena which we actually observe. Again, if the tracks be made beneath the water, on light, loamy mud, it is easy to see that waves or currents might produce slight movements in the successive deposits, without destroying the impressions. Or if the surface were slightly inclined, gravity would produce the same effect on such mobile materials. Plate VI., fig. 2, shows the manner in which tracks sometimes pass through successive layers of the rock. This may represent the case where the animal descended a slope. Fig. 1 shows how the layers are bent by the three front toes. The lateral ones do not extend so deep as the middle toe, and such is usually the case

In general, we find but little difference in the size of the tracks on successive layers; yet, upon the whole, the tendency is to enlarge downwards. Sometimes the enlargement is considerable, and I have known a claw to appear on the lower layer, but rarely phalanges, which did not appear at the top.

These examples, to which I might add more, show how careful we ought to be not to confound the impressions of the same track on different layers with different species. Nothing but long experience in ichnological researches will prevent such mistakes.

The number of toes (to return to the character which we were considering) varies in the tracks from two to five. Three and four are the most usual numbers.

From the details that have been given, we see that this character, although important, is in some cases of difficult determination.

9. *Absolute and relative length of the Toes.*—In these characters there is a good deal of constancy; and hence they afford good grounds for specific and even generic distinctions.

There are, however, some difficulties in the determination of these points. One is, the uncertainty that often exists, whether the track before us exhibits the very surface on which the animal trod. If it be above or below that plane, the toes will always be too short, although their relative length (the most important character) may not be essentially altered. But the greatest difficulty lies in determining how far backward the toes extend; that is, where the toes end and the heel begins. In the thick-toed tracks, this point can generally be decided with accuracy. But in the narrow-toed tracks, especially if they are digitigrade, and if their divarication is small, we can get only an approximate measurement of the length of the toes. The rule which I have usually followed, where it could be adopted, has been, to measure the lengths of the toes of the leptodactylous tracks, from the point where the lateral front toes prolonged backward cross each other. This at least does well for the relative, if not for the absolute, length of the toes. In the pachydactylous species I have measured from the end of the claw to the posterior extremity of the proximal phalanx.

These characters are more important and more easily ascertained in those tracks which have only three toes directed forward and these nearly straight, than in those with a greater number directed forward, or which are much curved. In the first-named tracks, I find the fourth or hind toe always the shortest; the inner toe, of the three directed forward, the next longest; the outer one, still longer; and the middle one, the longest of all. This, I believe, agrees with the relative length of the toes of birds. Where four toes are directed forward, the same order is observed. It is generally the same in the five-toed species. But sometimes the outer toe but one is longest, and the outer one much the shortest, as in many of the living Ranidæ.

10. *Divarication of the lateral Toes.*—In many living species, as, for example, the Palmipedes among birds, this is a very constant and reliable characteristic. Nor is this constancy confined to the web-footed animals. Where the toes are free, they diverge at a pretty constant angle; and so it seems to be with the fossil footmarks. I speak now of those where three toes are directed forward; for the chief application and use of this character are confined to these. They do, indeed, diverge a few degrees more or less in different specimens; but the variation is so limited, that a practised eye often recognizes a species by this mark. In the thick-toed species the angle is measured by prolonging the axes of the toes, that is a line drawn through the middle of the toe, backward till they intersect: and as they do not always meet in the same point, the sum of the divarication of the outer toes with the middle toe, is sometimes slightly greater than that of the lateral toes. In the narrow-toed species the axes of the toes form the angles, but in this case the tip of the toe is always used for one extremity although the curve of the toe is sometimes so great that what I call its axis, is really its chord. In the thick-toed species the claw is neglected.

11. *Angle made by the inner and middle Toe, and the outer and middle Toe.*—These angles are perhaps not quite as constant as that between the lateral toes; for in treading upon the mud, the strain upon the foot seems sometimes to have varied a little the position of the middle toe. Still, this character ought not to be neglected. In some instances, the

curvature of the toes is so great, that it is difficult to measure the angles described under this and the preceding heads.

12. *Projection of the middle Toe beyond the lateral ones.*—This is not exactly equivalent to the difference in length between the middle and lateral toes, because the middle toe generally does not reach backward so far as the others. It is an important and constant character, and serves to distinguish several species; as the *Argozoum dispari-digitatum* from the *A. pari-digitatum.*

13. *Distance between the tips of the lateral Toes.*—This is determined by the angle of divarication and the length of the lateral toes; but as it would need the solution of a case in trigonometry, it is easier to measure the distance; for it is useful in comparing one track with another.

14. *Distance between the tips of the middle and the inner and outer Toes.*—These elements are also determined by the previous ones; but it is more convenient to measure than to calculate them. It is obvious that they are among the permanent characters, and therefore useful for settling the genus and species.

15. *Position and direction of the hind Toe.*—This character applies only to those tracks that have three toes directed forward, and a single one behind. And it is obvious that the latter may have a great variety of positions and directions, and furnish, therefore, (since these characters are constant in the same species,) good indices of different species. In many species of birds, the hind toe is simply the outer toe prolonged backwards, bringing the fourth toe (*pouce* of the French) always on the inside of the foot. And this is its situation in the fossil tracks; as in the *Ornithopus gallinaceus* and *gracilior.* In the *Plectropus minitans* it is short, and proceeds from a long heel, a little behind the origin of the toes, at right angles nearly to the heel, like the spur of the domestic cock. In the *Tricænopus leptodactylus* it is very slender, proceeding from about the same place on a long heel, but directed forwards, so as to make quite an acute angle with the heel. In the *Polemarchus gigas* this toe, which is quite stout, proceeds laterally from a very thick, rounded heel, at right angles to the axis of the foot. When this toe runs directly backward, it is difficult to distinguish it from a narrow heel; as in the *Corvipes lacertiloideus,* Plate XVII., fig. 3. In this case I have indeed considered this projection as a heel. But the track of the snow-bird *(Fringilla Hudsonia)* Plate VI., fig. 8, is almost exactly like Plate XVII., fig. 3, except the short outer toe; and it is a hind toe that makes the posterior impression in the Fringilla.

In dissecting some specimens of *Plectropus,* I have been struck with another fact. On the highest layer the fourth toe appears to project at right angles with the heel, and some distance back from the roots of the other toes. But a little farther down we find its extremity turned backward, and its other end forward, until at length it lies nearly on a line of the outer toe backward, which is a characteristic of another genus, the *Ornithopus;* and as the heel frequently disappears, the track is likely to be confounded with the *Ornithopus gallinaceus,* although generally they appear very much unlike. This singular change of position in the hind toe I find it very difficult to explain by any of the hypotheses which I have suggested above, in describing the fourth character.

16. *Claws and Pellets.*—These in living animals are merely a horny case, more or less enveloping the terminal phalanx; in most cases, however, prolonged into a rounded or accuminate body, generally curved downward. Hence the impression made by them will really be in fact that of the phalanx; nor is it possible in the track to say where the one ends and the other begins. But I reckon all the impression as made by a claw, which has the form of a very acute triangle proceeding from the rounded extremity of the toes. This, however, in a few cases, as in Amblonyx, Plate XIII., figs. 1 and 2, seems to be rounded almost into a semicircle; which I have thought might indicate wings to the claw; as in a few living birds: but it is perhaps quite as probable, that it is referrible to the manner in which the common claw impressed the mud.

Some living animals, especially of the Batrachian family, have some of the toes terminated by knobs or pellets, rather than by claws. And so it was with some of the Lithichnozoa: as in Otozoum Moodi, Plesiornis pilulatus, and Cheirotheroides pilulatus.

Doubtless claws existed upon all the narrow-toed species of tracks; which generally, however, show none distinct from the gradual acumination of the toes. A few exceptions are the Argozoum Redfieldianum and Apatichnus circumagens.

The ratio between the length of the claw and that of the foot, in some species where claws have been measured, is as follows:—

Brontozoum giganteum,	9.9	Brontozoum isodactylum,	5.7
" Sillimanium,	6.75	Grallator cursorius,	8.1
" validum,	5.9	Amblonyx Lyellianus,	6.2
" gracillimum,	6.2	Argozoum Redfieldianum,	6.2

These numbers do not differ from one another more, perhaps, than can be explained by uncertainties of measurement, which in the case of the claw must be considerable. Hence we may conclude that the length of the claw varies in the same proportion as that of the foot; at least, as nearly so as in living animals.

17. *Width of the Toes.*—I have attempted to apply this character only to the pachydactylous tracks, as the others are so nearly alike, and so narrow, that no importance would attach to the measurements. The numbers given in the description of the several species of thick-toed animals are obtained from the same specimen, and merely indicate the greatest and least breadth of the phalangeal protuberances. Usually these measurements can be made with a good degree of accuracy, and therefore this character is one of considerable importance.

The following numbers express the ratio between the average width of the toes in these several tracks, and the length of the foot:—

Brontozoum giganteum,	8.2	Brontozoum isodactylum,	5.3
" Sillimanium,	10.0	Grallator cursorius,	7.5
" validum,	5.8	Amblonyx Lyellianus,	5.8
" gracillimum,	6.2		

It is clear that the great differences in these ratios cannot be explained by inaccuracies of measurement; and hence the thickness or breadth of the toes is a good character by which to distinguish species; as, indeed, an inspection of the outlines of the pachydactylous tracks on Plates VIII. to XIII. will evince.

18. *Number and length of the phalangeal expansions.*—The number of phalanges in the toes of living animals is a most important and constant character. In the vertebrate classes they are as follows:—

In the mammalia (except in the Cetacea, where in one finger it rises to six and even eleven,) two in the thumb, or inner toe, and three in all the others.

In four-toed birds, the phalanges, reckoning outward, are two, three, four, and five.[9]

In three-toed birds, three, four, five.

In the two-toed ostrich, four, five.

In crocodiles, fore feet; two, three, four, four, three; hind feet; two, three, four, four.

In lizards, fore feet; two, three, four, five, three; hind feet; two, three, four, five, four.

In the chameleon, fore feet; two, three, four, four, three; hind feet, the same.

In batrachians, frogs, &c., fore feet; two, two, three, three; hind feet; two, two, three, four, three.

In salamanders, fore feet; one, two, three, two; hind feet; one, two, three, three, two.

In the siren, fore feet, two, two, two, two. No hind foot.

In the proteus, fore feet; two, two, two; hind feet; two, two.

Marine and fresh water tortoises; hind and fore feet, two, three, three, three, two. The Trionyx has four in the fourth hind foot.

Land tortoises; hind feet, two in each of the four toes. Fore feet, two in each of the five toes.

The distinctness and uniform number of phalangeal impressions on fourteen species of the fossil footmarks, is striking and remarkable. If the animal's feet in a petrified state were fastened to the slabs, they would not be more distinct and perfect than on such specimens as Nos. $\frac{10}{8}$ and $\frac{13}{4}$. So far as I have examined the feet of living animals, very few of them would exhibit near as much of symmetry, constancy and numerical exactness in the phalanges as shown externally. The protuberances on the integuments of the foot do not seem always to correspond to the phalanges, but to the articulations. This is always true as to penultimate and ungual phalanges. Indeed, I suppose that the ungual phalanx never makes an impression distinct from the claw and the penultimate phalanx. For often this terminal phalanx is little more than the nucleus of the claw, which gives it the same curved horn-like shape as itself assumes.

From these statements it follows I think, that in general the number of phalangeal impressions in a track will be one less in each toe than the number of phalanges; because the two outer ones will make but a single impression. This conclusion has an important application to the thick-toed fossil footmarks, which will be made in considering the

[9] Professor Spencer F. Baird informs me that the old-world Swifts (Cypselus and Melba) have but three joints to each anterior toe; and that the Caprimulginæ, or Goat Suckers, have but four joints in the outer toe.

affinities of the second group. I am not sure that the principle is true in all classes of animals, but I think it always is in birds.

It is sometimes difficult to distinguish between impressions made by the phalanges, and those of the metacarpal or metatarsal bones. The tracks of the anomalous *Otozoum Moodii* exhibit this difficulty more distinctly than any other, as the detailed description of that species will show. Plate XXII.

The number of phalangeal impressions on the tracks is greatest in the outer toe in all cases yet met with; and hence they are usually less distinct there,—so indistinct often that their measurement is difficult; and, indeed, the mere length of these impressions has not as yet been applied as a generic or specific distinction.

19. *Character of the Heel.*—The fossil footmarks show much variety in this part, and being a constant part, it is of much value in determining the nature of the animal. In very many cases the metacarpal or metatarsal bones seem to have been placed in so oblique a position, that neither they, nor the integuments beneath them, reached the ground; and we have accordingly only the imprint of the toes, as in the genera *Platypterna* and *Argozoum;* that is, the feet were digitigrade.

A more common case is where the cushion beneath the metacarpal or metatarsal bones made an impression, but the bones themselves left no indistinct imprint. This was usually the case with the pachydactylous tracks. But in the *Brontozoum Sillimanium* and one or two others a distinct impression remains of the double-headed extremity of what was probably a tarso-metatarsal bone; for, besides these two rounded impressions, we have the four others in the outer toe which all the other tracks exhibit. Many of the leptodactylous tracks exhibit an impression of the cushion beneath the bones that lie behind the toes, forming a heel which slopes upward and backward so gradually, that it is impossible to say exactly where it terminates. For the mud yielded a little beyond the margin of the track, and this fact, in many instances, is a great hinderance to finding out the exact size and shape of the foot, and moreover is the grand difficulty in giving a satisfactory representation of these tracks. For this reason, I have in some instances, in the accompanying sketches, left the posterior part of the heel without an outline.

In other cases, the posterior margin of a rounded heel is strongly marked, not, as we might at first suppose, because the animal sunk deeper on account of the peculiar state of the mud, but because it was a heavier animal, and one that trod more upon his heel; for we find the same deep impression wherever it trod. Examples of this sort are *Polemarchus gigas*, *Palamopus Clarkii*, and sometimes *Triænopus leptodactylus*.

A few species present us with a heel of a very peculiar character, of whose exact nature I am yet in doubt. Just behind the point where the toes originate, the surface in the track rises above the general level of the stone, while behind this ridge is a depression, in the bottom of which are minute ridges, radiating backward a considerable distance, the whole heel having the appearance of a brush. I formerly suggested, that this might have been produced by coarse hairs upon the animal's heel; but I now give up that idea, and imagine it to have been produced by radiating rugosities on the heel, or by the partial adhesion of the mud to the heel, as the animal raised its foot, conjoined with

the subsequent action of the water; and I have sometimes thought it possible that the whole might be merely slight ripple-marks. But whatever may have been the origin of these marks, we may be sure that a large and rather remarkable heel belonged to the animal.

The long and narrow heel is a common one in these footmarks. In many instances, it seems to have been made by a long metatarsal or metacarpal bone, which did not lie horizontally upon the ground, but was inclined at various angles, according to the manner in which the animal pressed upon it, and moved forward. Hence the imprint would vary in different specimens, and its posterior termination be difficult to fix exactly. This character is shown in *Plectropterna minitans*, where it is obvious from an examination of the specimens, that the heel lay in a sloping position. In the *Anomœpus*, *major* and *minor*, the whole of the tarsal or carpal joint is sometimes exhibited. At other times we see a graceful swelling out of the heel a little in advance of the tarsal or carpal joint, as in *Anomœpus*. The same is sometimes seen on *Plectropterna minitans*.

The long heel of the hind foot of *Corvipes* may have been a toe; indeed, it bears a strong resemblance to the posterior toe on the hind foot of the *Phyllurus Cuvieri (Dictionnaire Classique d'Histoire Naturelle*, Plate 120,) which are lizards. See Plate VI., fig. 10.

In some of the quadrupeds, the heel differs in the hind and fore feet; as, for example, the *Macropterna*, the one being long, and the other rounded.

The difference between the heel of the fore and hind foot is likewise well exhibited in the *Anomœpus minor*, and *Ancyropus heteroclitus*. This character alone would form a good one for generic, as well as specific distinctions.

In some cases, as in the *Apatichnus circumagens*, I have found a heel and a tail on the surface where the animal trod, but the toes indistinct; although an inch deeper the latter were well developed, but neither the heel nor tail were seen. This I suppose was the result of the condition of the mud on which the animal trod; it being too soft to retain the impression of the toes, but hard enough to show the heel and tail. In one or two other cases, (*Triænopus leptodactylus*,) the imprint of the rounded heel was not distinct except half an inch below the surface trod upon.

20. *Irregularities of the under side of the Foot.*—The depth of the impression in the rock, made by the different parts of the foot, show which of them projected farthest downward. In this way we ascertain that usually the middle toe was rather the most prominent on the bottom of the foot; at least, most of the weight of the animal pressed upon it; for we find, as already stated, that as we cleave off successive layers of the rock, the middle toe remains longer than the others. And of the middle toe, its central parts make the deepest impression; showing that that part bent downwards most. Of the toes, the fourth, or hind one, (where three are directed forward,) disappears first; showing that its articulation was higher up than the others. The heel generally vanishes next; proving that it was placed on a higher level than the body of the foot.

One cannot inspect a series of specimens of footmarks without seeing at once that a part of the animals that impressed them were plantigrade and a part digitigrade, and some calcigrade. Of the first, all the pachydactylous tracks *(Brontozoum* and *Otozoum)* are

examples; of the second, the genera *Argozoum* and *Platypterna*, furnish examples; and of the third *Polemarchus gigas* is a good illustration.

But there is an intermediate and remarkable variety, in which the heel and toes made a deep impression, but a space between them is left unimpressed, and not unfrequently rising above the original surface, either in a curve or a ridge. We have examples of this in *Tridentipes ingens* and *elegans*, in *Platypterna varica* (Plate XIV., fig. 8), and in *Triænopus leptodactylus.* In such cases it cannot be doubted that the long os calcis, or sometimes perhaps the carpal or tarsal bone, which formed the heel, was so articulated to the other bones of the foot as to constitute an arch, or even to form an angle, considerably acute, as in some quadrupeds; so that when the mud was impressed by the heel and the toes, it would be crowded upwards between them. This would exactly explain the appearance of some of the tracks above referred to; and it gives us an accurate view of the character of the bottom of the foot, and to some extent of its osseous structure. Sometimes the elevation of the rock, behind the toes, is irregular; indicating a corresponding irregularity on the bottom of the foot, as in *Tridentipes ingens* and *elegans.*

21. *Versed sine of the curvature of the Toes.*—Some species of the footmarks are remarkable for the curvature of the toes. In the tracks with three toes directed forward, the middle toe always curves towards the line of direction on which the animal was advancing, and the lateral toes usually curve outward near their tips. (See the figures of *Tridentipes insignis*, *Argozoum Redfieldianum*, the species of *Platypterna*, and of *Ornithopus.*)

In *Polemarchus gigas*, the outer toe curves slightly inward like the others. In most of the four and five-toed tracks, the curvature is all one way, so as to make the curves of the several toes somewhat concentric; sometimes towards the line of direction, as in *Harpedactylus* and *Isocampe;* at other times it is away from the line of direction, as in *Anomœpus minor* (the fore foot) and *Ancyropus heteroclitus.* The curvature of the hind toe is usually so small, that I have not attempted to measure it.

If a straight line be drawn from the root to the tip of the toe, and another perpendicular to it where the curve is most distant, the length of this last line, measured from the centre of the toe, I call the *versed sine.*

I have sometimes suspected that this curvature resulted from the position of the animal's feet in relation to the line of direction; so that when it made a muscular effort to urge forward the body, it would throw the toes into a curved position. But upon reflection, such a movement, it seems to me, would cause the toes to slide so much, that some vestige of the movement would remain, which I have never seen. I rather incline to the opinion, therefore, that this curvature is the natural state of the foot, and such as we see in many reptiles.

22. *Angle made by the axis of the Foot with the line of direction, or median line.*—By this I mean the course taken by the animal as it walked along the surface. To determine this accurately, we must have at least three tracks, and if possible four. The axis of the foot is a line drawn from the middle of the heel to the tip of the longest toe. Now in some species of animals, as they walk, these two lines nearly or quite coincide; as

in the Grallæ among birds. But in other animals, with short legs, or those whose feet diverge from the axis of the body, the divarication between these lines may be quite large. Nay, in some reptiles, (see Plate VI., fig. 12, the Salamandra Beechyi,) the hind foot is so situated, that it makes a very obtuse angle with the line of direction; and, in fact, the hind and fore feet point in nearly opposite directions; so that from the tracks alone one cannot determine in which direction the animal moved. It is obvious, then, that this is an important character, sufficient to distinguish species, and even genera.

23. *Distance of the middle of the Heel, or posterior part of the Foot, from the line of direction.*—I might have selected the tip of the longest toe as the point from which to measure, instead of the middle of the heel. But whichever extremity of the foot is used, the position of the other end is fixed, if we know the divarication between the axis of the foot and line of direction. And it is obvious that the distance to the right and left of the line of direction, at which we find the tracks, will depend partly and mainly upon the distance between the points of insertion of the legs upon the animal's body, and partly upon their length. Hence it must be a constant character, and cannot vary much in the same animal, except, perhaps, in some of the sprawling quadrupeds. I have never depended upon it alone to distinguish species; but I think it might be safely done, when the character is well marked.

24. *Length of the step.*—By observing in the description of species, the ratio between the length of the foot and the step, it will be seen that there is a general correspondence between the length of the foot and of the step. Yet the differences in the ratios make it equally obvious, that some of the animals were short-legged, and some long-legged. Some may suppose that these differences only show that the animals moved with different rapidity at different times. There is, indeed, a considerable diversity in the length of the step of the same species on different specimens; but such cases as the *Grallator cursorius*, *Typopus abnormis*, *Anisopus Deweyanus*, and *gracilis*, at one extreme, and *Otozoum Moodii* at the other, make it evident that each animal had its peculiar type of progress and of stride. Yet there is so much difference in that stride, at different times, that I have not depended on that character alone to establish a species.

In giving the length of the step in the quadrupedal tracks, I have measured from track to track of the same foot, where it is not otherwise mentioned.

25. *Size of the Foot.*—In a few instances the species of footmarks scarcely differ except in size; and the question arises, whether the smaller species should not be considered as the young of the other. This is possible. But then we ought to find specimens of every intermediate size, which has not yet been done. And besides, is it probable that very young animals would often frequent such thoroughfares as the localities of footmarks seem to have been, where so many sorts of animals resorted, and where, in the dearth of food that must sometimes have existed, the young ones must often have been devoured if present? Are living animals wont to bring their offspring into such places, till they have attained considerable size?

Considerations like these have led me to the conclusion, that where a good deal of difference in size exists in tracks, whose form differs but little, they were probably made by

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different species. Yet it is only where the difference in size is constant, or other characters are unlike, that I have founded species upon the circumstance of size. Brontozoum giganteum and Sillimani are good examples of tracks differing not greatly except in size: yet no one familiar with the subject would doubt that they are different species.

26. *Caudal Appendages.*—The first of these is the tail proper, which in most of the mammiferous animals is carried so high that it does not make a continuous trail upon the ground, except when the legs are quite short. In the kangaroo and some of the Rodentia, it forms quite a support for the body, making one of the three legs of a tripod. But such animals move by leaps, and, therefore, there is no continuous trail. Not so in lizards and chelonians, whose tails almost always drag more or less upon the ground. When, therefore, we find a trail of this sort on fossil tracks, the presumption is that the animal belonged to one of these classes.

In some instances we find the trace of the tail lying in a serpentine course, as if the tail swept to the right and left alternately, so as to carry it outside of the tracks. This would be the effect of long strides, especially if the animal were a biped; and such a trace may, therefore, give us some light as to both these particulars. If the animal moved nearly on a right line, and the tracks deviate but little from such a line, then will the tail trace generally pass through the tracks: or midway between them if the tracks are placed considerably to the right and left of the median line. If the animal changes its course, then will the tail be carried to the right or left of the tracks.

The advance of the tail dragging through the mud, must cause the mud to be arranged somewhat in minute ridges, pointing forward, so as to meet if prolonged at a small angle in the middle of the trace. If this appearance be reversed, we may be sure that the furrow was not made by the animal whose tracks indicate movement in an opposite direction.

In one species of fossil footmark we have an appendage differing from the tail of any living animal. The fossil one left several inches behind his hind feet, a somewhat heart shaped impression, almost circular, and strongly indented. It seems as if the blunt end of a stick had stuck the mud, at short distances. If the impressions were enough elongated we might suppose them produced by a kangaroo's tail at its successive leaps. But its form and some other circumstances excite doubts whether such was its origin. I will however go more into detail when I come to describe the *Anomœpus*, Plate VIII. At present I must regard this appendage as unlike existing nature, though it would require only some modification of the tail of *Phyllurus Cuvieri* to make a similar impression. See Plate VI., fig. 10.

27. *Trail of the Feet and Carapace.*—In the fossil footmarks the feet have more often left a trail than the tail. But generally the two can be distinguished. For the latter is usually more continuous and nearer the median line: the other touches the surface only occasionally, and is often more or less divergent from the median line.

Such trails are much more common when the animal had short legs, or sprawling ones, like lizards and chelonians. Hence where this character is present, it affords a presumption of the nature of the animal.

A still more specific character is the trace of a carapace. Such trails are broader than those of the tail, and often several appear, and always between the rows of footmarks. The appearance is that of a flat body with perhaps occasional inequality of margin, dragged over the surface.

28. *Width of the Trackway.*—By a trackway, in ichnology, I mean that belt of surface impressed by the body and extremities of an animal as it moved along. In some cases, the annelids for instance, it will be simply a furrow, since the animal has no limbs. In others, the feet attached to long and sprawling legs, will make tracks wide asunder. Hence much may be learnt from the trackway, of the nature of the animal; and a wide difference in this respect, would be sufficient to separate animals whose tracks were otherwise alike. If the trackway scarcely exceeds in width that of the single track, we may feel assured that the animal had long legs, and consequently the body was raised a good deal from the ground: but when the trackway is wide, and especially if the steps be short, we may safely infer a thick-bodied and more clumsy animal.

29. *Integuments of the Feet.*—These differ in the various classes of animals, and may serve as important marks of distinction. These differences are shown very finely on mud and clay; as, for instance, the delicate striæ of the human foot, contrasted with the pitted structure of birds, on Plate XXXII., fig. 1, from the banks of Connecticut River in Hadley. Nor are these delicate markings wanting in the fossil footmarks. For if a surface can retain the marks of the delicate and almost miscroscopic feet of insects, we should expect it to exhibit the forms of the striæ, pits, and tubercles, of larger animals' feet, as in fact it sometimes does.

30. *Coprolites.*—In connection with the Argozoum Redfieldianum a few very perfect coprolites have been found at Chicopee Falls. Their analysis by Dr. Samuel L. Dana has furnished him with an ingenious argument to show the nature of the animal by which they were dropped. He found in them about the same amount of uric acid as in the droppings of those birds that have produced guano, and hence infers that similar birds yielded the coprolites.

Coprolites of a similar aspect have been found by Roswell Field, Esq., at Turner's Falls: but they have not been analyzed. I think, also, that they occur quite frequently on the banks of Connecticut River in Northampton, but more changed in their mineral character.

31. *Anomalies of character, as shown by the Fossil Footmarks.*—After bringing into comparison the feet and tracks of living animals with the fossil footmarks, although we find numerous striking analogies, there still remain in the fossil impressions several peculiarities, to which living species furnish no counterpart. Or rather the fossil species present characters which are found in several distinct living animals.

This is no new principle in paleontology. The names in many instances given to fossil animals imply their alliance to two or more families; as the sauroid fishes, for instance, which are allied to saurian reptiles on one side and to fishes on the other. So the Ichthyosaurus was named on the same principle, as was, also, the Plesiosaurus. "In the first genus," says Cuvier, "we have the muzzle of the dolphin, the teeth of the crocodile,

the head and sternum of a lizard, the paddles *(pattes)* of a whale, though four in number, and finally the vertebræ of a fish: in the second genus, with the same extremities as the whale, we have the head of a lizard, and a long neck similar to the body of a serpent." *(Ossemens fossiles*, Tome V., p. 445.) Dr. BUCKLAND several years later presented the characters of the Ichthyosaurus probably with more accuracy: "Having," says he, "the vertebræ of a fish, as instruments of rapid progression; and the paddles of a whale, and sternum of an Ornithorhynchus, as instruments of elevation and depression, the reptile Ichthyosaurus united in itself a combination of mechanical contrivances which are now distributed among three distinct classes of the animal kingdom." *(Bridgewater Treatise*, Vol. 1, p. 185.)

In the same geological age lived the pterodactyle, of which no less than fourteen species have been dug out of the rocks, and of which CUVIER says: "Of all the creatures of the ancient world, these are incontestably the most extraordinary, and if we saw them alive would appear the strangest of living beings." (*Oss. Foss.*, Tome V., p. 379.)

Existing nature, however, is not destitute of examples of animals scarcely less heteroclitic, and combining characters of different classes. "In this anomalous animal, the ornithorhynchus or platypus," says Dr. BUCKLAND, "we have a quadruped clothed with fur, having a bill like a duck, with four webbed feet, suckling its young, and most probably ovoviviparous; the male is furnished with spurs."

CUVIER has indicated the rule by which we should be guided in assigning such peculiar organisms their true place, when he says, in reference to the ichthyosaurus and plesiosaurus: "In spite of the anomalies of their structure, these two animals approach nearer to the lizards than to any other genus." That is, we must judge of the animals true place by the predominance of characters. (*Oss. Foss.*, Tome V., p. 445.)

It is an interesting fact that the most remarkable of these peculiar animals occur in the oolitic series; the same as we now suppose to embrace our fossil footmarks. It would be strange, therefore, if none of these track-discovered animals showed anomalies and characters not now found in any one class of animals; they do furnish not a few most remarkable examples. I have been struck with the fact, when trying to refer the footmarks to the true class of living animals, that I seemed to approach the nearest to true analogues, when I examined the feet of animals near the limits of different classes, especially batrachians and lizards. Still, with some strong resemblances, the living species almost always seem to have characters less full and decided than the footmarks indicate. It seems as if the living ones were diminutive and depauperate representatives of races whose period of full development had long since passed away.

I shall not here go into a detailed description of the cases of anomalous footmarks that have fallen under my notice, but will merely refer to a few of the most striking.

When we look at the tracks of the *Anomœpus major* (Plate VIII.,) it seems as if we almost saw a huge frog sitting upon his haunches ready for a leap; but his fore feet have five toes, corresponding well with those of the kangaroo. Yet the hind feet have only three toes, and the distinctness of the phalanges makes it a perfect bird's foot, with a long heel; but the shape of the caudal appendage is different from a tail.

In the *Gigantitherium caudatum* and *minus*, (Plate XVI., fig. 1, and Plate XVII., fig. 1,) the animals seem to have been bipeds, yet they had tails, and birds' feet; the first and last characters allying them to birds, but the second to lizards.

Conclusions.

These thirty characteristics, based upon the principles of comparative anatomy and zoology, will afford us, it seems to me, reliable grounds from which to judge of the nature of an animal from its track. Some of the characters are, of course, far less decisive than others, and few of them singly would remove all doubt; but, if several of them conspire, they constitute strong evidence,—as strong as that by which the place of not a few fossil species are determined. If we should apply these characters to living animals, that is, attempt to determine their place on the zoological scale from their tracks, I think we might decide with a good degree of confidence upon the following points:—

1. Whether the animal is vertebral or invertebral.
2. Whether a biped, quadruped, or multiped.
3. To which of the four great classes of vertebrates, or the nine classes of invertebrates, (*Micographic Dictionary, Art. Animals,*) it belongs.
4. To what order. This is more difficult, and we should often fail.
5. To what genus. This is sometimes more difficult; for the feet of many genera are too much alike to be distinguished by their tracks. This difficulty, however, would tend to the formation of too few rather than too many genera.
6. To what species. And since a specific description embraces the whole animal, perhaps we should reach the truth more often as to species than genera or classes.

Adopting these principles as my guide, I have arranged the animals that made the fossil footmarks of the Connecticut Valley into the following groups, genera, and species. In making out the groups, I have brought those together whose tracks exhibit certain predominant analogous characters; but in several cases I have made these groups intermediate between existing classes. In all cases I have subdivided the groups into genera, and these into species; I can say only that this is the best result I can reach after twenty-three years study of these footmarks. But my own progress, as I look back upon my experience, admonishes me that more satisfactory conclusions will doubtless reward future ichnologists. I feel as if I had only commenced the work. Would that those who come after me could know how great have been the difficulties I have encountered, and how hard it has been to grope my way without guides through the thick darkness that has rested on this subject.

I cannot, without a clumsy circumlocution, suggest a known term which will embrace the animals whose characters I propose to describe from their tracks. In such a case, I believe it is lawful to resort to the Greek language, to furnish the desired word. I propose that of *Lithichnozoa*, from λίθος, a stone, ἴχνος, a track, and ζῶον, an animal; *the stony track animals*, or animals made known by their tracks in stone.

CLASSIFICATION OF THE LITHICHNOZOA.

KINGDOM ANIMALIA.

I. SUB-KINGDOM VERTEBRATA.

GROUP I.—MARSUPIALOID ANIMALS.

I. CUNOID MARSUPIALOIDS.

GENUS I.—Cunichnoides, (κύων ἴχνος and εἶδος.)
1. marsupialoids.

II. ORNITHOID MARSUPIALOIDS.

GENUS II.—Anomœpus, (ἀνόμοιος and πούς.)
1. major.
2. minor.

III. LORICOID MARSUPIALOIDS.

GENUS III.—Anisopus, (ἄνισος and πούς.)
1. Deweyanus.
2. gracilis.

GROUP II.—PACHYDACTYLOUS OR THICK-TOED BIRDS.

GENUS I.—Brontozoum, (βρόντης and ζῶον.)
1. giganteum.
2. minusculum.
3. tuberatum.
4. exsertum.
5. validum.
6. Sillimanium.
7. isodactylum.

GENUS II.—Amblonyx, (ἀμβλύς and ὄνυξ.)
1. giganteus.
2. Lyellianus.

GENUS III.—Grallator, (*Grallator.*)
1. cursorius.
2. tenuis.
3. gracillimus.
4. cuneatus.
5. formosus.

GROUP III.—LEPTODACTYLOUS OR NARROW-TOED BIRDS.

I. TRIDACTYLOUS.

GENUS I.—Argozoum, (Ἄργης and ζῶον.)
1. Redfieldianum.
2. dispari-digitatum.
3. pari-digitatum.

GENUS II.—Platypterna, (πλατύς and πτέρνα.)
1. Deaniana.
2. tenuis.
3. delicatula.
4. recta.
5. varica.
6. digitigrada.
7. gracillima.

II. TETRADACTYLOUS.

GENUS III.—Ornithopus, (πούς and ὄρνις.)
1. gallinaceus.
2. gracillior.

GENUS IV.—Tridentipes, (*Tridens* and *Pes.*)
1. ingens.
2. elegans.
3. elegantior.
4. insignis.
5. uncus.

GROUP IV.—ORNITHOID LIZARDS OR BATRACHIANS.

GENUS I.—Gigantitherium, (γίγας and θηρίον.)
1. caudatum.
2. minus.

GENUS II.—Hyphepus, (Ὑφή and πούς.)
1. Fieldi.

GENUS III.—Corvipes, (*Corvus* and *Pes.*)
1. lacertoideus.

GENUS IV.—Tarsodactylus, (ταρσός and δάκτυλος.)
1. caudatus.

GENUS V.—Apatichnus, (ἀπατέω and ἴχνος.)
1. circumagens.
2. bellus.

GENUS VI.—Plesiornis, (πλησίος and ὄρνις.)
1. quadrupes.
2. pilulatus.
3. æqualipes.

INCERTÆ SEDIS.

GENUS VII.—Typopus, (τύπος and πούς.)
1. abnormis.
2. gracilis.

GROUP V.—LIZARDS.

GENUS I.—Polemarchus, (πολέμαρχος.)
1. gigas.

GENUS II.—Plectropterna, (πλῆκτρον and πτέρνα.)
1. minitans.
2. gracilis.
3. angusta.
4. lineans.

GENUS III.—Triænopus, (τρίαινα and πούς.)
1. Leptodactylus.

GENUS IV.—Harpedactylus, (ἄρπη and δάκτυλος.)
1. Gracilis.

GENUS V.—Xiphopeza, (ξίφος and πέζα.)
1. Triplex.

GENUS VI.—Orthodactylus, (ὀρθός and δάκτυλος.)
1. floriferus.
2. intro-vergens.
3. linearis.

GENUS VII.—Antipus, (ἀντί and πούς.)
1. flexiloquus.
2. bifidus.

GENUS VIII.—Stenodactylus, (στενός and δάκτυλος.)
1. curvatus.

GENUS IX.—Arachnichnus, (ἀράχνης and ἴχνος.)
1. dehiscens.

GENUS X.—Chimæra, (Χίμαιρα.)
1. Barrati.

GENUS XI.—Isocampe, (ἴσος and καμπή.)
1. strata.

GROUP VI.—BATRACHIANS.

GENUS I.—Batrachoides, (βάτραχος and εἶδος.)
1. nidificans.
2. antiquior.

GENUS II.—Otozoum, (Ὦτος and ζῶον.)
1. Moodii.

GENUS III.—Palamopus, (παλάμη and πούς.)
1. Clarki.

GENUS IV.—Macropterna, (μακρός and πτέρνα.)
1. vulgaris.
2. divaricans.
3. gracilipes.

GENUS V.—Cheirotheroides, (χείρ, θηρίον and εἶδος.)
1. pilulatus.

GENUS VI.—Shepardia.
1. palmipes.

GENUS VII.—Lagunculapes, (*Laguncula* and *Pes.*)
1. latens.

GENUS VIII.—Selenichnus, (σελήνη and ἴχνος.)
1. falcatus.
2. breviusculus.

INCERTÆ SEDIS.

GENUS IX.—Hoplichnus, (ὁπλή and ἴχνος.)
1. equus.
2. poledrus.

GENUS X.—Saltator, (*Saltator.*)
1. bipedatus.
2. caudatus.

GROUP VII.—CHELONIANS.

GENUS I.—Ancyropus, (ἄνκυρα and πούς.)
1. heteroclitus.

GENUS II.—Chelonoides, (χελώνη and εἶδος.)
1. incedens.

GENUS III.—Helcura, (ἕλκω and οὐρά.)
1. caudata.
2. surgens.
3. anguinea.

GENUS IV.—Exocampe, (ἔξω and καμπή.)
1. arcta.
2. ornata.

GENUS V.—Amblypus, (ἀμβλύς and πούς.)
1. dextratus.

GROUP VIII.—FISHES.

GENUS I.—Ptilichnus, (πτίλον and ἴχνος.)
1. anomalus.
2. typographus.
3. pectinatus.
4. hydrodromus.

II. SUB-KINGDOM INVERTEBRATA.

GROUP IX.—CRUSTACEANS, MYRIAPODS AND INSECTS.

Genus i.—Harpagopus, (ἁρπαγή and πούς.)
1. Hudsonius.
2. dubius.

Genus ii.—Stratipes, (*Sterno* and *Pes.)*
1. latus.

Genus iii.—Hamipes, (*Hamus* and *Pes.)*
1. didactylus.

Genus iv.—Acanthichnus, (ἄκανθα and ἴχνος.)
1. cursorius.
2. saltatorius.
3. tardigradus.

Genus v.—Conopsoides, (κώνωψ and εἶδος.)
1. larvalis.

Genus vi.—Bifurculapes, (*Bis*, *Furcula*, and *Pes.)*
1. laqueatus.
2. tuberculatus.
3. scolopendroideus.
4. elachistotatus.

Genus vii.—Grammepus, (γραμμή and πούς.)
1. erismatus.
2. uniordinatus.

Genus viii.—Lithographus, (λίθος and γράφω.)
1. hieroglyphicus.
2. cruscularis.

Genus ix.—Hexapodichnus, (ἕξ, πούς and ἴχνος.)
1. magnus.
2. horrens.

Genus x.—Copeza, (κώπη and πέζα.)
1. triremis.

GROUP X.—ANNELIDANS.

Genus i.—Unisulcus, (*Unus* and *Sutcus.)*
1. Marshii.
2. intermedius.
3. minutus.

Genus ii.—Cochlichnus, (κόχλος and ἴχνος.)
1. anguineus.

Genus iii.—Cochlea, (κοχλίας.)
1. Archimedea.

Genus iv.—Halysichnus, (ἅλυσις and ἴχνος.)
1. laqueatus.
2. tardigradus.

Genus v.—cunicularius, (*Cucularius.)*
1. retrahens.

Genus vi.—Sphærapus, (σφαῖρα and πούς.)
1. larvalis.
2. magnus.

Detailed Descriptions.

Guided by the principles that have been laid down, I shall now attempt a scientific description of the groups, genera, and species in the preceding table. These descriptions must be drawn almost entirely from the tracks, and, therefore, in some cases are quite unsatisfactory. But future discoveries may clear up many of the difficulties.

The generic and specific names are usually derived from some obvious character of the track; so that if it should hereafter be found that I have referred the animal to the wrong family, its name will still be good, and convey no error.

It may be thought that I have made the number of species too large; it has seemed large to myself; but my conviction is that it is below the real number. When in 1848 I described fifty species, I thought it possible that I had in some instances mistaken varieties for species; but a careful re-examination of the whole subject has not discovered more than two or three errors of this sort, and most of the new species that have been since discovered, are very well marked. My descriptions, however, on the subsequent pages, will enable the comparative anatomist and zoologist to judge of the reliableness of my species. That I should in no case have mistaken different aspects of the same tracks on

different specimens, and made two species out of it, will hardly be thought probable, since in every department of paleontology, and even in zoology, where the entire animal is before the describer, mistakes of this sort are not unfrequently made. How much more liable to such errors must he be, who must found his distinctions upon tracks alone, and cannot in some cases be sure that he has the entire footmark before him!

But there are some considerations that lead us to expect to find that a large number of animals may have left their tracks upon the sandstone of the Connecticut Valley.

1. The Oolitic period, including the Lias, appears to have been unusually prolific of animal life, as the records of paleontology testify.

2. This valley must have been, as to climate and the relations of land and water, eminently adapted to attract and sustain a great variety of animals, especially such as live along the shores of estuaries and lakes. If I have rightly apprehended its condition, the climate must have been tropical, and the shores made still warmer, perhaps, by the trap rock beneath, yet retaining some of its original heat. It seems to have been an estuary, extending more than a hundred miles inward from the ocean, and traversed by several ridges in the form of islands, which divided it into several lakes. We can hardly conceive of a more agreeable spot for the habitat of animals, from the most gigantic to the most minute.

3. The large number of localities from which tracks have already been obtained, and their wide separation, would lead us to expect to find these relics of most of the animals that lived in the valley during the oolitic period.

The following are the localities of footmarks, as given upon the accompanying geological Map:—

Commencing at the most northerly point on the Connecticut, we find a locality on its north bank nearly opposite the mouth of Miller's River.

Another at the Horse Race.

Another on the opposite bank of the river at the same place.

Another near the Lily Pond.

Another in Roswell Field's orchard.

Another at the ferry above Turner's Falls, on the north bank.

Another on the same bank, a little below the Falls.

Another at the mouth of Fall River, close to the trap of Rocky Mountain.

Another at the locks of the canal at Turner's Falls, on the south shore.

Another one and a half miles south of this spot, just east of the canal, on the old road from Montague City to Grout's Corner.

Another between the bridges over Connecticut and Deerfield Rivers, in the north-east part of Deerfield.

Another in the south-west part of Montague, half a mile from the river at Marsh's Quarry.

In the road near Pliny Moody's, in South Hadley. Three others west of his house, within a half mile on a small stream; a fourth on the north side of the same stream, fifty rods north-east from his house; a fifth on the same stream, still farther east, just within

the limits of Granby; and a sixth on a hill a mile and a half north of the centre of South Hadley.

Another a few rods north-east of Mount Holyoke Seminary, in the same town, near a mill, and another half a mile south on the same stream.

Another at Smith's Ferry, on the east bank of the river, north of the road.

Another on the west face of Mount Holyoke, beneath the trap, a few rods north of Titan's Piazza, in Hadley. (Hoccanum.)

Another between the ridges of trap near Ashael Lyman's, in Northampton.

Another two miles south of Smith's Ferry, on the west bank of the Connecticut, close to the railroad in Northampton.

Another half a mile south-west of this spot, near the south end of Mount Tom.

Another at Bassett's Quarry, in Easthampton, south of Mount Tom.

Another on the east bank of the river, opposite the locality which is two miles south of Smith's Ferry.

Another along the canal, and in a quarry near the village of South Hadley Falls.

Another at Chicopee, in the quarries in the east part of the village.

Another in the bottom and north bank of Chicopee River, at Chicopee Falls.

Another one mile south of Chicopee, (Cabotville,) in a quarry on the east side of the road to Springfield.

Another in a quarry near Enfield Bridge, on the west bank of the river in Suffield.

Another at Rocky Hill, in Hartford.

Another at the Cove, in Wethersfield.

Another two miles south of this spot.

Another at the quarries in Portland.

Another in Middletown, at an old quarry two miles west of the city.

Another at what is called Middlefield, in the south-west part of Middletown.

Another at the ichthyolite locality, in Durham.

The most remote of these thirty-eight localities are distant from each other about ninety miles; which embraces, in fact, the whole length of the sandstone formation on the river. Below Durham it trends westerly, and extends several miles farther to New Haven; but no footmarks have been found below Durham.

In width the strata embracing the tracks do not extend more than two or three miles, as may be seen upon the Map; but the strip probably embraces most of the valley in which animals lived, and in these thirty-eight quarries we might expect to meet with a large part of the species that were common.

4. The thickness of the strata on which the footmarks occur strengthens this conclusion. At Turner's Falls they occur in the lowest, and nearly in the highest layers above the trap; that is, on strata nearly four thousand feet in thickness, taking the measurements already given as a guide. If we reduce the thickness one-half, we still have nearly a half mile left; and although the animals appear not to have essentially changed during the thousands of years necessary to deposit so much rock, we do stand a good chance of finding most of the species then living, by opening several quarries along

the section, as has been done. I know of no other place where the tracks are found through such a thickness of rock; but at the east foot of Mount Tom layers several rods thick show them, and they are found on the opposite bank of the river; and how much farther to the east I cannot say.

5. The belt of rocks on which we find footmarks is usually only a few feet wide, and its longest direction usually corresponds to what must have been a shore at the time they were impressed, and that appears to have been the common pathway of all the animals that would frequent the shores of an estuary or lake. We might expect, therefore, to find in so many quarries representatives of most of the Fauna of sandstone days. But one hundred and nineteen species forms only a small part of the present Fauna of this valley.

The drawings appended to this Report are indispensable to convey an accurate idea of the footmarks. I have adopted several methods of obtaining the sketches, which I will describe.

For obtaining outline sketches I have sometimes laid over the specimens plates of smoked glass, or pieces of tracing paper or cloth, and traced the outline of the tracks upon it, and then transferred it to paper. In the quite small tracks, however, I have sometimes touched them (when in relief,) with some coloring matter,—say a red pencil,—and then pressed upon the slabs a piece of rather thin paper, which would retain the exact form and position of the tracks.

In most cases where the slabs containing the larger tracks could be placed upon their edges, I have secured ambrotype sketches of them, which have served as models for the lithographer. In not a few cases I have covered the larger slabs with tracing cloth, and marked the outline of all the tracks upon it; so that the ambrotype and the outline sketch might both be pretty sure to give the lithographer a correct idea of the specimen.

Where the slabs are so large and heavy, or so much cracked that they could not be placed upon the edge, I have resorted to the method of drawing squares upon the specimen, and transferring the tracks to corresponding squares upon paper, by the eye. In such cases I have represented each track as complete, although many are defective in some part; but in such cases I take special care to know what the species are which I thus restore.

I have made it a point of particular attention to give a representation of each species, with a few exceptions; either a simple outline, or an ambrotype sketch, of the natural size. I do not believe that otherwise an accurate idea could be given; for though the length and breadth of a diminished drawing could be stated, figures make but a slight impression upon the mind compared with a sketch. To show the tracks as they occur on the different slabs, ambrotype sketches are probably best, except when they are very small, as the tracks of myriapods and insects, when by the method already described a far better idea of them can be obtained if we leave the slab nearly or quite unshaded.

In 1848 I expressed the opinion that "for the discrimination of species, outline sketches are better than full-shaded drawings of individual specimens, because they

present more distinctly the essential characters." And notwithstanding the splendid full-shaded and even-colored drawings of Sir WILLIAM JARDINE, in his "Ichnology of Anandale," and of ISAAC LEE, Esq., in his "Fossil Footmarks of Pottsville," I still remain of the same opinion. What we want is the exact shape and size of the foot; and if the geologist cannot tell what that is, by having several specimens before him for comparison, much less can the reader do it from the most finished sketch of one of them. Such drawings show the skill of the artist, but the best of them that I have seen do not give as clear an idea of the track as a mere outline, and are, besides, very expensive. If the geologist mistake the character of the track in any respect, he can be corrected if he refers to the specimens in a cabinet, as he ought to do, from which his sketch was derived. I defy the most acute naturalist to discriminate species from the most finished drawings I have seen; but he could do it from outlines, though still better from specimens.[10]

It will be seen, then, that the engravings attached to this Report are of four kinds: 1. Outline sketches of nearly every species of tracks of the natural size. These give the idea, in my own mind, of the tracks, after examining all the specimens within reach, most of which are in the Ichnological Cabinet. They are, in fact, *restored tracks.* 2. Outlines of slabs, with all the tracks upon them, generally reduced, but restored; omitting deficiencies which any of them may exhibit. 3. Outline rows of particular species of tracks, taken out from others, and shown alone, but exhibiting all the imperfections of the originals. The object is to show how the animals placed their feet in walking. 4. Ambrotype sketches of the principal slabs in the Cabinet. These give the tracks, with whatever imperfections they have, just as they appear upon the specimens, and occupying their true relative position. But the lithographer, at my request, has omitted all other irregularities upon the slab, in order to give the tracks more distinctness. This division of the sketches exhibits quite a large number of what I call *stony volumes;* that is, specimens showing the same track on from two to five leaves. 5. The fifth division shows a few examples of single tracks from ambrotype sketches; they are intended to be exact copies of the originals, but a good deal reduced; the true size being marked upon the border. These, perhaps, are the least instructive of all the varieties of the drawings, and therefore I have given but a few.

By these various methods I hope I have conveyed to readers a clear idea of the different kinds of tracks, and their degree of perfection, as well as relative position; and that, too, without a quarter part of the expense that must have been incurred to give all the inequalities of the stones in the highest style of art; although the number of Plates has necessarily been large.

I ought to add, that the ambrotype sketches of slabs as well as of single tracks, and the outline rows of tracks, are not reduced to any one fixed standard as to size; for I found that unless I made the large tracks and slabs of unwieldy dimensions, the smallest, exhibited in proper proportion, would be of almost microscopic littleness. I thought it a less evil to let the engraver make the drawings of any convenient size that would

[10] The late Hugh Miller expressed similar views in a lecture on the Geology of Scotland.

exhibit all the tracks, taking care only that all the tracks on each specimen should be shown of a true proportional size in relation to one another, but not in relation to other specimens. Hence the same tracks on different specimens may be of different sizes; but as the true size of each slab is given on its margin, should any one desire it, he can reduce the whole to the same scale.[11]

In the following descriptions I shall first present the characters of the Group, and then of all the genera and species in the group. Then, where I can, I shall state the affinities of the Group to existing classes and orders of animals.

The Appleton Ichnological Cabinet.

Specimens of the tracks of all the fossil animals described in this Report, and also of several living animals on clay, will be found in the Appleton Ichnological Cabinet, and will be referred to under the several species. As numbers are painted or engraved upon the specimens, instead of being placed upon tickets, they will furnish a means of reference as permanent as the Cabinet itself.

I have already given some account of this Cabinet in the commencement of my Report; but a few other circumstances will not be out of place.

An end or front view of this building is given on Plate IV., fig. 1, as taken by ambrotype. Fig. 2 will give a good idea of its appearance inside, as seen by one looking in through the front door. The long room is lighted only from one side, (the south side,) while on the opposite side is a gallery, leading at the farther extremity into a lecture room, and having several doors on the left side opening into rooms for duplicate specimens. On the left hand side of this gallery, also, the wall is covered by glazed cases for the smaller and more delicate specimens. Suspended from the ceiling, towards one of the windows, (see drawing,) hangs a specimen of the foot and leg of the great Palapteryx ingens, dug out of the soil in New Zealand, and large enough to have made nearly the largest of the fossil tracks on the tables beneath. Still farther to the left, is suspended a cast of the egg of the Æpiornis maximus, dug from the soil in Madagascar, and the original of which is in the Garden of Plants in Paris. This egg is thirteen and one-half inches long and thirty-three and one-half inches in circumference; equal to one hundred and forty-eight hen's eggs and fifty thousand humming-bird's eggs!

It has been found that in order to have the footmarks show themselves most advantageously, the light must be made to fall on them obliquely. Hence where it could be done, the large tables occupying the area of the cabinet, are made to slope from the bottom of the windows towards the gallery; so that specimens placed upon them might be seen in the best light by persons walking through the gallery. The best mode of all, is to place the specimens on their edges on tables running across the hall, as has been done with many of the best and largest; some of them being from eight to ten feet square, and weighing nearly a ton. Such an arrangement has the advantage, also, of exhibiting both sides of the specimens, which often have tracks depressed on one side and in relief on the other.

[11] Of the ambrotypes which I had taken, one hundred and thirty were executed by E. W. Cowles, and thirty by Mr. Gilbert. Four very fine ones, (Plate V., figs. 1 and 2, XXIX., fig. 5, and LX., fig. 1,) in addition, were taken by J. L. Lovell.

Some might suppose that the tracks would show much better if the gallery were to run along on the opposite side of the room, immediately beneath the windows. But experiment showed, that with perhaps now and then an exception, the exhibition would be much less distinct and satisfactory.

In arranging the specimens upon the tables and in the cases, I was led to count the number of individual tracks in the whole Cabinet, and found them to be not less than *eight thousand.* This would give an average of sixty-eight tracks for each species. But in fact the specimens of some species are five, or even ten times more numerous than of others.

LITHICHNOZOA.

KINGDOM ANIMALIA.

SUB-KINGDOM, VERTEBRATA.

Remark. — The names prefixed to the twelve Groups that follow, will sufficiently indicate their characters without a formal statement.

GROUP I. — MARSUPIALOID ANIMALS.

Remarks. — I commence a detailed description of the fossil footmarks with the latest discovered species, specimens of which were not obtained till my Report was just ready to be put into the printer's hands. But the first inspection of these specimens satisfied me that the tracks differed not a little from all others which I had found. Indeed, they look very much like the tracks of a large dog, and I have made this fact the foundation of the generic name, yet I can discover no claws upon the rounded toes, nor have I found more than four toes with a central impression, which seems to be the ball of the foot, and which is almost always seen upon a dog's track. At first it seemed that I could hardly avoid placing this species in some tribe of Mammalia higher in organization than the Marsupial. But I think that one of the feet, — the fore one probably, — was smaller than the other, and it is safer therefore to regard it as a Marsupial, since we know such animals to have been quite abundant in the Jurassic period, as the recent discoveries of Mr. Beckles in England prove. He has disinterred not less than fourteen species of mammals from the upper oolitic strata. Most of these are Marsupials: yet some of them are Carnivora, of the family Insectivora. There would be, therefore, no presumption against the opinion that some of the Lithichnozoa stood as high on the zoological scale.

I make three divisions of the first Group: 1. Cunoid Marsupialoids; embracing only one genus and one species. 2. Ornithoid Marsupialoids; one genus and two species 3. Loricoid Marsupialoids; one genus and two species.

I. — CUNOID MARSUPIALOIDS.

Genus I. — CUNICHNOIDES, (κύων, a dog, ἴχνος, a track, and εἶδος, appearance; a track resembling a dog's.)

Quadrupedal: fore feet rather the smallest. Ball of the foot making a distinct impression on the mud, with at least four circular impressions arranged nearly on a semicircle in front of that made by the ball.

Species 1. Cunichnoides marsupialoideus. (Nov. Sp.)

[In the Cabinet, $\frac{29}{2}$.]

Hind Foot.— Impressions made by the ball of the foot, circular, as well as by the toes: all of them about 0.6 inch in diameter. Claws (if any) not long enough to make a separate mark. Diameter of the whole foot, 1.5 inch, by 2.3 inches. Length of the step from track to track of the same foot, 16 to 18 inches (?). Distance of the two lines of tracks from each other, about 5 inches. Number of toes, 4. Width of the trackway, 11 inches.

Fore Foot.— Very closely resembling the hind foot, except that it is some smaller: the circular impressions of the toes rarely exceeding 0.5 inch. The tracks of the hind and fore feet almost always interfere, so that rarely more than eight distinct impressions remain. Most of these are quite deep, and appear as if so many round sticks had been thrust into the mud.

An outline of two of these tracks, which I suppose to be hind and fore feet, is given on Plate IX., fig. 5. These are copied from No. $\frac{29}{2}$ in the cabinet, which was presented to it by the Shaler and Hall Quarry Company, at Portland, Connecticut.

Plate LX., fig. 2, gives the outline of the most important part of a large and heavy slab of these tracks belonging to the Middlesex Quarry Company, at Portland. It shows probably more than the tracks of one animal, and illustrates the manner in which the tracks of the hind and fore feet are intermixed.

Figs. 3 and 4 of Plate LX. exhibit a reduced outline of two specimens, (the first of which, No. $\frac{29}{3}$,) is in the Ichnological Cabinet, which have excited considerable interest from their resemblance in form, and of the first in size, to the human foot. I have not seen these impressions in succession, and do not feel prepared to express an opinion as to the nature of the animal that made them; except that it was not man. But I think I can see the trail of a toe in front of the impression, and do not doubt that some huge animal made them. There are some strange markings at the Portland quarries that need examination. My fear is, that the specimens will be so scattered that it will be difficult for any one to make the comparisons requisite to settle their nature. They ought to be collected into some one cabinet.

Sub-Group II.— ORNITHOID MARSUPIALOIDS.

Animals vertebrated, quadrupedal, three to five-toed, plantigrade; the hind feet calcigrade, hind legs buttressed by a stout caudal appendage.

Genus II.— ANOMŒPUS. (From ἀνόμοιος, unlike, and πούς, the foot. The animal with unlike feet.)

Hind feet plantigrade, three (four?) toed, all the toes pointing forward; ornithoid, phalanges distinctly impressing the mud in walking. Heel long, extending to the tarsal joint; its posterior part making a deep, rounded impression. Fore foot quinquefid, rather digitigrade; all the toes pachydactylous, with acuminate claws. A caudal appendage,

with blunt extremity, left an impression when the animal rested, as if a blunt stick had been pressed into the mud.

Species 1. Anomœpus major. (Nov. Species.)

[In the Cabinet, $\frac{1}{1}$, $\frac{20}{1}$, $\frac{29}{1}$, $\frac{30}{2}$, $\frac{16}{1}$.]

Hind Foot.—Tridactylous, pachydactylous, unguiculate, tuberculated, ornithoid. Heel long, making an impression at its posterior extremity on mud as deep as the toes. Space between the extremity of the heel and the roots of the toes forming a broad arch upward, so that the whole heel often did not impress the ground in walking. Divarication of the lateral toes, 26°; of the inner and middle toe, 20°; of the middle and outer toe, 10°; of the axes of the feet with each other, 23° to 30°. Length of the inner toe, 3.5 inches; of its proximal phalanx, 1.6 inch; of its second phalanx, 1.4 inch; of its ungual phalanx and claw, 0.6 inch; of the middle toe, 6 inches; of its proximal phalanx, 1.6; of the second and third, the same; of the ungual phalanx and claw, 1.2 inch; of the outer toe, 4.2 inches; of its proximal phalanx, 0.6 inch; of the second phalanx, 1.1 inch; of the third, (third and fourth?), 1.4 inch; of the ungual phalanx and claw, 0.8 inch; of the heel behind the toes, 9 inches; of the whole foot, 16.5 inches; of the step, or leap, 10 to 22 inches. Breadth of the inner toe, average, 1.15 inch; of the middle toe, 1.5 inch: of the outer toe, 1.2 inch; of the heel at its posterior part, 2.1 inches; of the trackway, 17 inches. Distance between the tips of the lateral toes, 4 inches; between the inner and middle toe, 3.5 inches; between the middle and outer toe, 4 inches. Projection of the middle toe beyond the rest, 3.2 inches; lateral distance between the posterior extremities of the heels, 8 inches; ditto between the middle toes, 12 inches. Right foot of the track in advance of the left, 2 to 4 inches.

Fore Foot.—Pentedactylous, pachydactylous, unguiculate, marsupialoid, plantigrade. Axis of the feet turned outward; distance between the middle of the feet, 7.7 inches; divarication of the outer toes, 83°; of the inner and second toe, 6°; of the second and third, 32°; of the third and fourth, 20°; of the fourth and fifth, 26°. Length of the inner toe, 1 inch; of the second, 1.5 inch; of the third, 1.6 inch; of the fourth, 1.3 inch; of the fifth, 0.7 inch; of the foot, 2.4 inches; width of ditto, 2.3 inches; of the toes, average, 0.5 inch. Length of the claws, 0.2 inch.

Caudal Appendage.—Behind the hind feet of the tracks of this animal, about seven inches distant, and midway between the heels, we find a somewhat heart-shaped impression, as if a stick from 2 to 3.5 inches in diameter, and rounded at the posterior part in the shape of a heart, and pointed at the other end, had been pushed with considerable force into the mud. It did not usually drag like a tail, but on one specimen in the Cabinet we find the impression repeated at the distance of ten inches, as if the animal moved by leaps; or if, as is probable, this appendage served as a buttress, while the animal rested upon its long tarsus, it might have been raised from the ground at each step of the animal, even though it did not leap.

The tracks of all the feet of this animal, in their normal position, are shown on Plate VIII. The successive impressions of the caudal appendage are shown on

Plate XLIV., fig. 5, although it is somewhat doubtful whether any track is shown with them.

Locality.—The only place where this species has been found is in the footmark quarry near the house of ROSWELL FIELD, Esq., in Gill. One specimen is in his possession, and another in the Appleton Cabinet; and, although each of them is deficient in some parts, by examining both I have obtained the above characters. Mr. FIELD'S specimen shows the impression of the tail and the heel, reaching from the toes backward, but a large part of the toes are broken off. The Amherst specimen, however, has one foot very distinct, and the posterior extremity of both heels; though only two phalangeal impressions can be found upon the left hand foot, as shown in Plate XXXVIII., fig. 2. The fore feet, also, are seen upon this specimen, but do not show the toes distinctly. These I have supplied from a third specimen, which shows a fore foot very perfectly, except the phalanges. Mr. FIELD discovered the mark of the tail upon his own specimen, and pointed it out upon that in Amherst College, where it is less distinct. I am satisfied that it must have been made by some sort of a caudal appendage; I think it must have been the extremity of this that made the impression, though some of the marks look as if a part of the under side of the tail reached the ground.

Plate VIII. will give a good idea of the manner in which this animal rested when sitting upon its bent hind legs, and the resemblance to the position of a huge frog is very strong. So the successive marks of the tail, at intervals of ten inches, gives the impression that it moved by leaps. Some other circumstances, however, have excited doubts in my mind whether this was its usual mode of progression; but perhaps this point can be better understood after describing the second species.

Species 2. ANOMŒPUS MINOR.

Anomœpus scambus of Fossil Footmarks of the United States, Plate XIII., figs. 1 to 6.

Described, also, by Dr. Deane, in the American Journal of Science, Vol. XLIX., p. 80, and Vol. III., N. S., p. 78.

[In the Cabinet, $\frac{16}{2}$, $\frac{16}{4}$, $\frac{19}{7}$, $\frac{19}{14}$, $\frac{23}{3}$, $\frac{34}{40}$, $\frac{40}{2}$, $\frac{41}{52}$.]

Hind Foot.—Tridactylous, pachydactylous, tuberculated, ornithoid. Divarication of the lateral toes, 42°; of the inner and middle toe, 20°; of the middle and outer toe, 22°. Toes nearly straight; average width, 0.8 inch. Length of the inner toe, 2.3 inches; of the middle toe, 3 inches; of the outer toe, 3.3 inches; of the heel, 4 inches; of the foot, 8.2 inches; of the step, 9 inches. Projection of the middle toe beyond the rest, 1.2 inches; distance between the tips of the lateral toes, 2.7 inches; between the inner and middle toes, 1.9 inch; between the middle and outer toes the same. Phalanges on the inner toe, three, (?) 0.7, 0.7, 0.8 inch, commencing with the proximal; three on the middle toe, 1, 1, and 0.7 inch; five on the outer toe, 0.8, 0.8, 0.6, 0.6, 0.6 inch. Angle between the axes of the feet and the line of direction, 20°; between the axes, 10°. Distance between the heels, 4 to 5.8 inches; advance of one heel beyond the other in the tracks, 2 inches; width of the trackway, 8 inches.

Fore Foot.—Pentedactylous, pachydactylous, unguiculate, plantigrade, marsupialoid. Axes of the feet somewhat turned outward; angle made by the inner and second toes, 40°; between the second and third, 50°; between the third and fourth, 12°; between the fourth and fifth, 11°; between the inner and outer toes, 114°. Length of the inner or hind toe, 1 inch; of the second, 1.2 inch; of the third, 1.4 inch; of the fourth, 1.3 inch; of the fifth, 0.9 inch. Phalanges of the hind or inner toe, 2, 0.4, 0.4 inch; of the second toe, three, (?) 0.3, 0.3, 0.4 inch; of the third, four, 0.4, 0.3, 0.3, 0.3 inch; of the fourth, 3, 0.4, 0.3 inch. Distance of the middle of the heel from the line of direction, 2 inches.

Caudal Appendage.—If I mistake not, we find an impression of this on at least two specimens in the Ichnological Cabinet, one of which is shown on Plate IX., fig. 1, by the ovoid space marked with dotted lines. It may possibly be the heel of another track; but as we have two specimens in the Cabinet almost exactly alike, and no track near enough to be connected with them, I presume they are the marks of a tail, analogous to that connected with the tracks of Anomœpus major. The tail in the A. minor, judging from this sketch, may have been more like the common tail of a marsupial, or a lizard, than that of the other species.

Plate IX., fig. 1, shows the tracks of the four feet of this species, from a specimen in the Ichnological Cabinet; but this does not show the phalangeal impressions. These were ascertained with some degree of certainty from a fine slab, 22 by 45 inches, in the possession of T. Leonard, Esq., of Greenfield, which I was permitted to examine several years ago, and of which Plate XXXIV., fig. 2, is a reduced copy. The Ichnological Cabinet contains several specimens, but this of Mr. Leonard's is the best ever found. I am not sure that we can determine from it the exact number of phalanges, but we approximate to the number. Plate IX., fig. 2, gives a reduced sketch of the best hind and fore foot on this slab.

Locality, Turner's Falls.—From a single imperfect specimen in the Cabinet, I formerly suggested that this animal's leg above the tarsal joint sometimes reached the ground; but a re-examination of the specimen leads me to doubt this. Indeed it could be only an animal with very sprawling legs whose second or third joint could reach the ground; and an inspection of Plate IX., fig. 1, shows that this animal did not thus spread out its limbs.

I have been more perplexed to determine the nature and mode of progression of the animals of this genus, from their tracks, than in respect to almost any other of the one hundred and nineteen described in this Report. The facts which we now possess respecting these tracks, have been very slowly developed. The frequent failure of the whole heel in both species of Anomœpus to reach the ground, leaving often a space of several inches between the impression of the posterior part of the heel and the foot with which it belonged, and the great resemblance between the foot and that of birds, led at first to the doubt whether the two were connected. But numerous specimens have now dispelled that doubt; and when one looks at such tracks as shown on Plates VIII. and IX., it seems as if they must have been made by enormous frogs sitting upon their hind

bent legs, with the fore feet resting a little in advance upon the ground. But there are several difficulties in the way of such a supposition; the toes of living frogs are usually terminated by pellets instead of claws, though there is one species, of which a sketch is given on Plate VI., fig. 11, the *Dactylura capensis*, which has claws. Again, Batrachians generally have only four toes on the front foot, but here we have five. Once more, the frog when at rest turns its fore feet inward, but these are turned outward. And, finally, the frog has no tail such as we find to have been possessed by the Anomœpus.

Being thus thrown into great doubt as to the Batrachian origin of these tracks, we turn next to the Marsupials; and here, it must be confessed, we find some strong analogies. Those with unequal feet, as the kangaroo, have five toes in the fore foot, which are placed, when the animal brings them to the ground, as in the Anomœpus. Originally the hind foot has five toes also; but they usually, in some species, become consolidated into three, though you will sometimes see two claws on a toe. The long heel, also, of the Anomœpus, corresponds to that of the kangaroo tribe; and though its caudal appendage seems not to have made such an impression as would that of the kangaroo, yet in both it seems to have been one of the legs of a tripod on which the animal rests, and is buttressed up by it.

The character of the hind foot is, I think, the strongest argument against the marsupial origin of the Anomœpus tracks; it is so exceedingly like a bird's foot, such as will be shortly described, that when seen separated from the heel we should rarely suspect that it belonged to a different animal. In the A. major, even the phalanges correspond with those of a bird, except, perhaps, in the outer toe; and in the most perfect specimen known, that represented on Plate VIII., it is quite possible that four phalangeal impressions may have been made, for the distal phalanx, as I have described it above, is long enough for two, though I can discover but one on the stone. I cannot believe, however, so distinct are the imprints, that the inner toe had more than two; although taking living Mammalia as our guide, all the toes should have three. In the A. minor, also, though I still doubt whether we can consider the number of phalanges to be settled, as far as we do know, the correspondence is rather with birds than with Mammalia. But I shall add some further remarks on this point, when I come to that of the affinities of the second Group.

There is another difficulty in the distinctness and breadth of the phalangeal impressions. I have never seen the track of a Marsupial with unequal feet, but I cannot conceive it possible that the consolidated toes of its hind feet should have phalanges so distinct and expanded. Indeed this character in many of the fossil footprints is more marked than in any living animals that I know of, and constitutes one of the peculiarities that distinguish the fossil from living species.

To enable those who read this Report to form a better idea of the relations of the Anomœpus to Marsupials, I have given on Plate VII., figs. 23 and 24, sketches of the hind and fore feet of the Hypsiprimnus pencillatum and Perameles obesula, two Marsupials from Australia, whose feet correspond more nearly to the tracks of Anomœpus than any other species of that family.

In view of all these facts my mind still balances upon the question, in what class of animals shall we place the species of Anomœpus? I have called them Ornithoid Marsupialoids; but perhaps they might, with nearly equal reason, be called Ornithoid Batrachians. Indeed, if a phrase so compound could be used as should imply a participation in the characters of marsupials, birds, batrachians, and even lizards, it would better than any other express my present convictions; for the longer I study these tracks, the stronger my impressions become that some of these ancient animals possessed characters now more exclusively belonging to two, three, or even four classes. Nor is it yet possible, in all cases, to decide which characters predominate. Even when the bones have been found of animals of the same geological age as the tracks, the zoologists have not yet been able to agree upon the place of some species. How much more difficult where the tracks only remain!

A few words as to the mode of progression in the Anomœpus tribe. When we see its position, as it rested upon all its feet and tail, so like that of a frog, and especially when we observe that the tail did not drag, but struck the ground only at intervals, we naturally conclude, that like the frog or kangaroo, it must have advanced by leaps. But another fact, obvious in every track which I have seen, should be taken into the account; one hind foot is always in advance of the other,—an indication of progress by steps, at least with the hind feet. Yet this is not the case to any extent with the fore feet. I have conjectured that the animal had two or three modes of advancing, which it could use at pleasure; sometimes it might use only its hind feet and tail, lifting up the latter as it rose upon its feet, to step forward; then it might bring down its fore feet, and make them the pivot for throwing forward its posteriors by a partial somerset, or a one-sided impulse. But, perhaps, if I had been more familiar with the movements of marsupials on disproportioned legs, I might not be obliged to leave this point in so much uncertainty.

Sub-Group III.—LORICOID MARSUPIALOIDS.

Animals vertebrated; four to five toed, mostly pointing forward: moving forward nearly on a right line. Legs and step long.

Genus III.—ANISOPUS, (ἄνισος, unequal, and πούς, foot: the animal with unequal feet.)

Hind feet four-toed, all pointing forward; fore foot five-toed, four pointing forward; thick, rounded at the end. Animal walking nearly on a right line, and bringing up the hind foot nearly into the place just left by the fore foot.

Species 1. Anisopus Deweyanus.

Ornithichnites parvulus. Mass. Report, 1840, Plate 39, fig. 26.

Sauroidichnites Deweyi of Transactions of American Association of Geologists and Naturalists, Plate 11, fig. 9.

Anisopus Deweyanus of Fossil Footmarks of the United States, Plate XVI., figs. 5 and 6.

[In the Cabinet, $\frac{1}{3}$, $\frac{3}{1}$, $\frac{4}{1}$, $\frac{21}{1}$, $\frac{20}{6}$, $\frac{26}{5}$, $\frac{26}{10}$, $\frac{16}{1}$, $\frac{29}{1}$, $\frac{32}{16}$, $\frac{39}{9}$, $\frac{41}{51}$.]

Hind Foot.—Divarication of the inner and second toes, 12°; of the second and third, 23°; of the third and fourth, 6°; of the inner and outer, 40°. Length of the inner toe from the posterior extremity of the foot, 1 inch; of the second toe, 1.5 inch; of the third, 1.7 inch; of the fourth, 1.5 inch; from tip to tip of the lateral toes, 1.1 inch; average width of the toes, 0.3. Toes rarely showing phalangeal impressions or claws; angle of the axis of the foot with the median line, 15° to 30°; distance of the middle of the heel from the median line, 1.5 inch. Length of the step, 7 to 7.5 inches. Width of the trackway, 2 to 3 inches.

Fore Foot.—Five toed, tuberculated. Divarication of the inner and second toes, 53°; of the second and third, 13°; of the third and fourth, 18°; of the fourth and fifth, 24°; of the inner and outer, 107°. Length of the inner toe, reckoned from the centre of the heel, or posterior extremity, 0.3 inch; of the second ditto, 0.8; of the third, 1 inch; of the fourth, 1 inch; of the fifth, 0.6 inch. Distance from tip to tip of the lateral toes, 0.75 inch. Tracks of the fore foot usually made a little on the inside of that of the hind foot.

Both the hind and fore feet of this species, or rather an outline of their tracks, are shown on Plate IX., fig. 3; beautiful rows of the same are shown on Plates XLI., fig. 2, XLII., figs. 1 and 2, and LIII., fig. 8. Many of these on the stones appear larger than the outlines given on Plate IX., fig. 3, and probably the specimen chosen from which to obtain the above description does show a rather smaller track than the largest, but it is quite distinct. The fifth toe on the fore feet, being very short, and looking at first almost like a heel, is rarely seen. Plate LVIII., fig. 11, shows a single hind and fore foot as they appear on the slab.

This species is dedicated to my early and distinguished friend, Rev. Professor CHESTER DEWEY, LL. D., of Rochester, New York.

This was the first animal whose tracks were recognized as those of a quadruped in the Connecticut Valley. I first described them in my Massachusetts Report in 1840, as those of a bird; three toes only being visible on a slab from Middletown, though I suggested their resemblance to those of a marsupial animal; but in 1842, I redescribed the species under the name of Sauroidichnites Deweyi, in the Transactions of the Association of American Geologists and Naturalists, and I there stated that "this is the first example in which any of the numerous tracks upon the sandstone of the Connecticut Valley were made by a quadruped." What a progress there has been in this respect since that time, fifteen years ago; for in this Report I expect to describe not less than fifty-four species of four footed animals!

Species 2. ANISOPUS GRACILIS.

Anisopus gracilis.—Footmarks of United States, Plate XVI., figs. 3, 4.

[In the Cabinet, Nos. $\frac{9}{4}$, $\frac{10}{3}$, $\frac{13}{1}$, $\frac{16}{1}$, $\frac{16}{10}$, $\frac{17}{4}$, $\frac{19}{4}$, $\frac{19}{5}$, $\frac{20}{4}$, $\frac{20}{6}$, $\frac{21}{1}$, $\frac{21}{3}$, $\frac{23}{8}$, $\frac{24}{1}$, $\frac{26}{7}$, $\frac{26}{8}$, $\frac{26}{19}$, $\frac{26}{20}$, $\frac{29}{1}$, $\frac{29}{6}$, $\frac{29}{8}$, $\frac{32}{12}$, $\frac{32}{18}$, $\frac{32}{45}$, $\frac{33}{17}$, $\frac{33}{28}$, $\frac{33}{37}$ $\frac{33}{48}$, $\frac{34}{8}$, $\frac{35}{41}$, $\frac{35}{43}$, $\frac{36}{20}$, $\frac{36}{44}$, $\frac{37}{11}$, $\frac{37}{12}$, $\frac{37}{21}$, $\frac{37}{23}$, $\frac{38}{16}$, $\frac{40}{62}$, $\frac{32}{14}$.]

Hind Foot.—Four-toed, increasing in length to the third, the fourth rather shorter; all directed forward. Phalangeal impressions sometimes seen on the track, with a claw

on all the toes except the fourth. Divarication of the outer toes, 40°; of the inner and second toes, 15°; of the second and third, 10°; of the third and fourth, 15°. Length of the inner toe from the middle point of the heel, hind part, 0.4 inch; of the second toe, 0.8 inch; (length to its root in the heel, 0.65 inch,) of the third toe, 0.9 inch; (to its root, 0.6 inch,) of the fourth, 0.85 inch; (to its root, 0.5 inch,) of the foot, 1 inch. Width of the inner toe, 0.1 inch; of the others, 0.15 inch. From tip to tip of the lateral toes, 0.8 inch. In the inner toe, two phalanges; in the second, three; in the third, three; in the fourth, three. (?). Angle between the axis of the foot and the line of direction, 10° to 20°, outward. Distance of the heel from the median line, 0.25 to 0.6 inch. Width of the trackway, 2 inches. Length of the step, as large as 5.6 inches. Claw on the three inner toes only, of the width of a pin, and 0.1 inch long.

Fore Foot.—Toes, five; outer ones very short, and rarely seen on the track, all pointing forward. Divarication of the lateral toes, about 60°; of the inner and second, 15°; of the second and third, 20°; of the third and fourth, 10°; of the fourth and fifth 10°. Length of the inner toe, 0.25 inch; of the second toe, 0.5 inch; of the third, 0.6 inch; of the fourth, 0.45 inch; of the fifth, 0.2 inch. Claws on all the toes except the two outer ones. From tip to tip of the outer toes, 0.4 inch. Position of the track in walking a little within and slightly in advance of the hind foot, and the axis is more nearly coincident with the line of direction. Width of the inner and outer toes, 0.05 inch; of the others, 0.075 inch.

An outline of the tracks of this species is given on Plate IX., fig. 4, taken from one of the best specimens in the Cabinet. The specimens there are numerous and some of them are shown on Plate XLIII., figs. 3, 4 and 5, and Plate XXXVI., fig. 1, shows a row of tracks from a slab owned by ROSWELL FIELD, Esq. The object of this last sketch is to show how nearly in a right line the animal moved. Plate LVIII., fig. 9, shows an ambrotype sketch of a single hind and fore foot.

Localities.—The finest localities are at Turner's Falls, at the Ferry below the Falls, in Mr. FIELD's orchard, and at Lily Pond. Also in South Hadley, in several spots, in Northampton, east side of Mount Tom, and at Middletown.

Affinities of the Sub-Group.—The tracks of the Anisopus have certainly very much of a Loricoid or Crocodilian aspect. I mean so far as the form of the foot is concerned. For lizards have four hind and five fore toes; and moreover, one of their hind toes has no claw, nor upon two of their fore toes, as in the Anisopus. Again the number of phalanges so far as they have been ascertained in the Anisopus, correspond. In the crocodile it is two in the inner, three in the second, and four in the two other toes, and we are sure that it is the same in the two inner toes of the Anisopus gracilis, and not sure but it may have four in the others. It would seem, then, from these characters that we have in the Anisopus minute species of the crocodile tribe.

But there is another character that makes it quite sure that they could not have had the structure of crocodiles, alligators, or gavials, or any of the scaly lizards; and that is the position of their tracks when walking. These succeed one another usually almost in a right line. (See Plate XXXVI., fig. 1, and Plate XXXV., fig. 5, which are given on

purpose to exhibit this fact.) Now such an arrangement of quadrupedal tracks can be made only by an animal walking upright and with long legs. No existing lizard, batrachian, or chelonian, could walk in this manner. But the cat, dog, fox, &c., do leave tracks thus arranged. All the reptiles above named must leave two rows of tracks wide apart. And therefore, we have a strong presumption in such rows of tracks, that the animal which made them must be of the mammiferous class. The inequality of the front and hind feet points us to the marsupials among the mammifers; and since these appear to have been the earliest of this class that appeared on the globe, they are the ones most likely to have made the tracks. But although the marsupial type must have predominated, the loricated or crocodilian characters, already indicated, ought not to be overlooked, and, therefore, I call the animal a *Loricoid Marsupialoid.*

I ought to add, that this rectilinear arrangement is no unusual occurrence in the quadrupedal tracks of sandstone clays, as the subsequent descriptions and annexed Plates will show; and there are some others, as the *Gigantitherium*, *Hyphepus*, *Plesiornis* and *Plectropterna angustus* and *lineans*, which have nearly as strong a claim to be placed under this Group as the *Anomœpus* and *Anisopus.* But at present I let them stand in other connections.

I can hardly help referring here to the well-known Chirotherium Barthii of Europe; well known I mean by its tracks. True, the specimens of these tracks in the Ichnological Cabinet (Nos. $\frac{26}{11}$, $\frac{26}{12}$, $\frac{26}{13}$,) are not on slabs large enough to enable me to judge accurately of their appearance in succession. But all the drawings of them which I have seen, and if I do not misrecollect, those on the large slabs in the British Museum, and in the collections at Liverpool, show these tracks arranged nearly on a right line. (Ex. gr. those in Dr. Buckland's Bridgewater Treatise, Plate 26.) Now some eminent naturalists have referred this animal to the Batrachian class. Professor Owen has attempted to identify it with the Labyrinthodon, and has given an outline sketch of one of these animals, leaving his tracks behind him. But highly as I respect the opinions of this eminent man, I cannot believe that such an animal as he has figured, could have left its tracks in a right line, or any where nearly in a right line. They must have been wide apart and could never have formed such nearly rectilinear rows as are shown on Dr. Buckland's Plate. It seems to me, therefore, that those who refer these animals to Marsupials, are sustained by the strongest evidence.

GROUP II. — PACHYDACTYLOUS OR THICK-TOED BIRDS.

Genus I. — BRONTOZOUM. (From βρόντης, a giant, and ζῶον, an animal; the giant animal.)

Foot tridactylous, pachydactylous, clawed, inner toe shortest; all the toes directed forward. Phalanges, exclusive of the ungual, two on the inner toe, three on the middle, and four on the outer toe. Foot plantigrade; cushion beneath sloping upwards posteriorly. Outer and posterior process of the outer distinct articulation of the tarso-metatarsal sometimes making an impression on the ground, through the cushion Integuments of the foot papillary and striated.

Species 1. Brontozoum giganteum.

Ornithichnites giganteus. — American Journal of Science, Vol. XXIX., Plate I., and Buckland's Bridgewater Treatise, Plate 26 [b]. London. 1836.

Ornithoidichnites giganteus, Final Report on the Geology of Massachusetts, Plate 36, fig. 18.

Ornitichnites giganteus; Pictet's *Traite de Paleontologie*, Tome Premier, p. 406, Plate XX., fig. 8. Seconde Edition. 1853. Paris.

Ornithichnites and Ornithoidichnites giganteus. — Bronn's *Index Paleontologicus, Zweite Halfte*, p. 851. Stuttgart. 1848.

Emprientes physiologiques, M. Aleide D'Orbigny's *Cours Elementaire de Paleontologie.* Premier Volume, p. 27.

[Specimens in the Ichnological Cabinet, Nos. $\frac{2}{1}$, $\frac{2}{3}$, $\frac{2}{4}$, $\frac{2}{5}$, $\frac{2}{7}$, $\frac{7}{1}$, $\frac{8}{1}$, $\frac{9}{9}$, $\frac{9}{10}$, $\frac{9}{11}$, $\frac{10}{1}$, $\frac{12}{7}$, $\frac{13}{6}$, $\frac{15}{1}$, $\frac{15}{2}$, $\frac{15}{3}$, $\frac{15}{4}$, $\frac{15}{5}$, $\frac{15}{6}$, $\frac{15}{7}$, $\frac{15}{8}$, $\frac{15}{9}$, $\frac{15}{10}$, $\frac{15}{11}$, $\frac{15}{12}$, $\frac{15}{13}$, $\frac{15}{14}$, $\frac{15}{18}$, $\frac{16}{6}$, $\frac{16}{13}$, $\frac{17}{1}$, $\frac{20}{6}$, $\frac{23}{9}$, $\frac{24}{1}$, $\frac{25}{2}$, $\frac{28}{1}$, $\frac{29}{1}$, $\frac{31}{22}$, $\frac{34}{2}$, $\frac{34}{6}$, $\frac{35}{3}$, $\frac{38}{4}$.

Description. — Divarication of the lateral toes, 40°; of the inner and middle toes, 20° to 25°; of the outer and middle toes, 15°. Length of the middle toe, 12.5 inches; of the inner toe, 10 inches; of the outer toe, 12.5 inches; of the foot, 14 to 18 inches; of the step, 3 to 5 feet. Width of the toes, 2 to 3 inches; of the posterior part of the foot, 6.5 inches. Length of the claw, 1.75 inch. Distance between the tips of the lateral toes, 12 inches; between the tips of the outer and middle toes, 7 to 8 inches; between the inner and middle toe, 7.45 inches. Length of the middle toe, beyond the lateral ones, 5.5 inches; of the first phalanx of the inner toe, 3.7 to 3.8 inches; of the second, 3.7 to 4.7 inches; of the first phalanx of the middle toe, 2.8 to 4 inches; of the second, 3 to 3.1 inches; of the third, 2.3 to 2.9 inches; of the proximal phalanx of the outer toe, 3.1 to 3.5 inches; of the second, 2.8 to 3.2 inches; of the third, 2 to 2.1 inches; of the fourth, 2.3 to 2.5 inches. Angle made by the axis of the animal's foot with the median line, or line of direction, as it walked, 0° to 10°. Distance of the centre of the heel from the median line, 0 to 5 inches. Width of the trackway, 18 inches. Toes nearly straight; middle one slightly curved inwards. Claws nearly straight and only slightly curved downwards. Integuments of the under side of the foot papillary and striated. Animals gregarious. Track shown of the maximum size on Plate X.

Plate XXXIII., fig. 1, shows a row of seven of these tracks of rather less size, on a slab in the Cabinet from Northampton, about 30 feet long. Plate XXXIII., fig. 2, shows another of three tracks of the largest size, from the same locality. On Plate XXXIII., fig. 3, we have four of these tracks of moderate size, surrounded by many of other species. Plate XLI., fig. 1, has two tracks of this species from Turner's Falls, of maximum size, with several smaller kinds of analogous character. Plate LIII., fig. 7, represents a *stony volume* of this species, occupying a *centre table* in the Cabinet. It is not as perfect as some others; but it is very rare to obtain this species in the book form. This comes from the most northerly point on the river where tracks are found. Plate LVII., fig. 1, exhibits a reduced sketch of a single track; the first one ever discovered, which was figured of the natural size in the American Journal of Science and in Buckland's Bridgewater Treatise.

Localities.—One has just been indicated, viz.: at a point in Gill, nearly opposite the mouth of Miller's River. It occurs, also, at the Horse Race and Lily Pond: at the Ferry above Turner's Falls: between the bridges over Connecticut and Deerfield Rivers, in Deerfield: at all the localities in the north part of South Hadley, and in Northampton at the east foot of Mount Tom: this indeed is the most abundant locality. Here are found several parallel and some intersecting rows of this species of track, which often run oblique to what must have been the direction of the shore where they were made. These facts make the gregarious character of the animals probable.

Advancing southerly, we find this species at Chicopee Falls, Enfield Falls, Wethersfield Cove, at the Portland Quarries, and especially in the south-west part of Middletown. We thus ascertain its former existence through the whole length of the valley. The first track of this species which I found, (that which was figured in the American Journal of Science for 1836, and afterwards in Buckland's Bridgewater Treatise,) I threw aside at first, because I could not believe that an impression three or four times larger than that of the great African ostrich's foot, could be a track. But this animal turns out to have been one of the most common of all that trod upon the muddy shores in liassic days. For a time I regarded it as the giant ruler of the valley. But subsequently I have found the tracks of others that might have successfully disputed the palm of superiority with it, as subsequent descriptions will show.

We have specimens in the Ichnological Cabinet larger than the one I have figured: or rather with wider but not longer toes. One from Northampton, No. $\frac{15}{1}$, will hold four quarts of water. No. $\frac{15}{4}$ is the cast of one obtained by DEXTER MARSH from the same locality, the original of which is in the Cabinet of the Boston Society of Natural History, having been purchased for one hundred dollars. It holds two quarts of water. Now I think that neither of these specimens show the true size of the toes; but that the tracks are below the layer on which the animal trod. His weight depressed several layers of mud below the surface, and if the mud was stiff the depression would enlarge downwards; so that when hardened into stone, and split open, a surface below where the animal trod would show a broader (not longer) track than the original. That in these cases the surface is not that on which the animal trod, is manifest from the fact that the phalangeal impressions have disappeared. In all such cases I am jealous of a track as affording the true size of the foot. No. $\frac{15}{1}$, however, does certainly appear as if the animal trod upon the surface now exposed. But the claws are not well exhibited and I incline to the opinion that such was the state of the mud that the foot left an exaggerated impression, as we often see among the tracks of living animals. The rule I have adopted in such cases is this: the more perfect the track in all its parts, the more sure may we be that the true form and size of the foot are represented, and *vice versa.*

Species 2. BRONTOZOUM MINUSCULUM. (Nov. Sp.)

[Specimens in the Cabinet, Nos. $\frac{1}{3}$, $\frac{5}{3}$, $\frac{6}{1}$, $\frac{14}{4}$, $\frac{16}{1}$, $\frac{17}{1}$, $\frac{20}{8}$, $\frac{33}{8}$, $\frac{33}{9}$, $\frac{33}{35}$, $\frac{34}{29}$, $\frac{35}{3}$, $\frac{33}{51}$, $\frac{20}{6}$, $\frac{25}{2}$.]

Divarication of the lateral toes, 50°; do. of the inner and middle toes, 25°; do. of the middle and outer toes, 25°. Length of the middle toe, 7.5 inches; of the outer toe,

8.5 inches; of the inner toe, 6.25 inches; of the middle toe beyond the others, 4 inches; of the claw, 1.5 inch; of the foot, 12 inches; of the step, 1 ft. 3 inches to 2 ft. 3 inches. Length of the proximal phalanx of the inner toe, 2.5 inches; of the second, 2.5 inches; of the first of the middle toe, 2.5 inches; second do., 2.25 inches; of the third do., 2.25 inches; of the first in the outer toe, 2.5 inches; of the second, 2.1 inch; of the third do., 1.75 inch; of the fourth do., 1.75 inch. Distance between the tips of the lateral toes, 7.3 inches; between the inner and middle toes, 5.3 inches; between the middle and outer toes, 5.3 inches. Angle between the axis of the foot and the median line, inward, 0° to 20°. Width of the trackway, 12.5 inches. Outline track shown of the natural size on Plate XI., fig. 1; also on Plate XL., fig. 2, and Plate XLI., fig. 1, two successive tracks are shown, and three on Plate XLII., fig. 3. On Plate LVII., fig. 2, is exhibited a single reduced track.

Localities.—Lily Pond quarry, in Gill, has furnished the most numerous specimens. It occurs, also, in the south part of Northampton, on the bank of Connecticut River.

This species might be regarded as only a smaller example of B. giganteum; but the great uniformity of its characters from the different localities, and their perfection, as well as some differences in form, strike the practiced observer as indicating a distinct species. Tracks like entire animals, or plants, frequently exhibit a peculiar type, by which the eye distinguishes one species from another, even where it is difficult to describe the difference in words.

This species has left an elegant track, especially as shown on Plate XL., fig. 2, from which the outline on Plate XI., fig. 1, was taken.

Species 3. Brontozoum tuberatum. (Nov. Sp.)

[Specimens in the Cabinet, Nos. $\frac{10}{6}$, $\frac{14}{4}$, $\frac{20}{6}$, $\frac{22}{1}$, $\frac{22}{6}$, $\frac{25}{1}$, $\frac{27}{17}$, $\frac{29}{1}$, $\frac{35}{6}$, $\frac{34}{15}$, $\frac{23}{1}$, $\frac{30}{2}$, $\frac{36}{5}$, $\frac{37}{15}$.]

Divarication of the lateral toes, 25°; of the inner and middle toes, 17°; of the middle and outer toes, 8°. Length of the inner toe, 5.5 inches; of the middle toe, 6.75 inches; of the outer toe, 8 inches; of the foot, 9.75 inches; of the step, 31 inches; of the first phalanx of the inner toe, 2.75 inches; of the second, 2 inches; of the middle toe, first phalanx, 1.88 inch; of the second, 2 inches; third do., 2 inches; of the claw, 1 inch; of the outer toe, first phalanx, 1.5 inch; second do., 1.62 inch; third do., 1.37 inch; fourth do., 2.25 inches. Width of the phalanges, 1.75 to 2 inches. From tip to tip of the lateral toes, 6 inches; inner and middle toes, 4.5 inches; middle and outer toes, 3.62 inches. Extension of the middle toe beyond the lateral ones, 2.62 inches. Angle of the axis of the foot with the median line, 0° to 10°. Width of the trackway, 8 inches. Outline of the track of natural size shown on Plate XI., fig. 2, copied from the stony volume No. $\frac{27}{11}$, exhibited on Plate LII., fig. 7, from an ambrotype sketch.

Locality.—Lily Pond, near Turner's Falls.

Remark.—This species differs from the B. minusculum, not only in being smaller, but in the much less divarication of the outer toes, and in the nearer approach to a circular form of the phalanges, especially the first one on the middle toe.

Species 4. Brontozoum exsertum. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{5}$, $\frac{1}{6}$, $\frac{2}{2}$, $\frac{2}{3}$, $\frac{2}{6}$, $\frac{5}{6}$, $\frac{5}{9}$, $\frac{5}{5}$, $\frac{5}{7}$, $\frac{5}{4}$, $\frac{5}{14}$, $\frac{6}{4}$, $\frac{6}{5}$, $\frac{9}{11}$, $\frac{9}{14}$, $\frac{10}{1}$, $\frac{10}{6}$, $\frac{12}{7}$, $\frac{13}{4}$, $\frac{13}{5}$, $\frac{13}{6}$, $\frac{13}{7}$, $\frac{14}{4}$, $\frac{16}{1}$, $\frac{16}{6}$, $\frac{16}{11}$, $\frac{20}{1}$, $\frac{20}{6}$, $\frac{22}{15}$, $\frac{25}{1}$, $\frac{26}{22}$, $\frac{30}{1}$, $\frac{31}{5}$, $\frac{31}{7}$, $\frac{31}{43}$, $\frac{32}{48}$, $\frac{32}{22}$, $\frac{31}{72}$, $\frac{39}{2}$, $\frac{39}{1}$, $\frac{40}{4}$, $\frac{41}{11}$, $\frac{41}{33}$.]

Divarication of the lateral toes, 30°; of the inner and middle toes, 15°; of the middle and outer toes, 15°. Length of the inner toe, 4 inches; of the middle do., 6.25 inches; of the outer do., 6 inches; of the foot, 8.75 inches; of the step, 30 inches; of the first phalanx of the inner toe, 1.5 inches; of the second do., 1.5 inches; of the first on the middle toe, 2 inches; of the second on do., 1.5 inch; of the third do., 1.5 inch; of the first on the outer toe, 1.25 inch; of the second on do., 1.25 inch; of the third, 1.44 inch; of the fourth, 1 inch; of the claw with the ungual phalanx, 1.25 inch. Width of the phalanges of the inner and outer toes, 1 to 1.25 inch; of the middle toe, 1.25 to 1.75 inch. Distance between the tips of the lateral toes, 4.75 inches; between the inner and middle toes, 4.5 inches; between middle and outer toes, 3.5 inches. Projection of the middle toe beyond the outer ones, 3.33 inches; width of the trackway, 6 inches. Angle between the median line and the axis of the foot, outwards, 0° to 5°. Outline track of the natural size, shown on Plate XII., fig. 1; taken from slab No. $\frac{16}{6}$, on Plate XL., fig. 3, from an ambrotype sketch.

Localities.—Most abundant at the east foot of Mount Tom, in Northampton, but common at Turner's Falls, and occurring at Portland.

Remark.—The most striking character of this species is the unusual projection of the middle toe; which character has hardly justice done to it in the drawings.

Species 5. Brontozoum validum.

Ornithichnites tuberosus, in part, American Journal of Science, Vol. XXIX., p. 318, and in Massachusetts Final Geological Report, Plate 37, fig. 20.

Brontozoum loxonyx of the Fossil Footmarks of the United States, p. 172, Plate II., figs. 1 and 2.

[In the Cabinet, Nos. $\frac{1}{1}$, $\frac{1}{2}$, $\frac{2}{1}$, $\frac{2}{2}$, $\frac{2}{3}$, $\frac{2}{6}$, $\frac{5}{5}$, $\frac{5}{6}$, $\frac{5}{7}$, $\frac{9}{8}$, $\frac{10}{1}$, $\frac{13}{4}$, $\frac{13}{6}$, $\frac{14}{4}$, $\frac{15}{6}$, $\frac{15}{16}$, $\frac{15}{17}$, $\frac{16}{4}$, $\frac{16}{6}$, $\frac{16}{9}$, $\frac{17}{1}$, $\frac{20}{5}$, $\frac{20}{6}$, $\frac{21}{1}$, $\frac{24}{1}$, $\frac{25}{2}$, $\frac{26}{22}$, $\frac{29}{1}$, $\frac{31}{16}$, $\frac{31}{17}$ $\frac{31}{18}$, $\frac{31}{19}$, $\frac{31}{20}$, $\frac{31}{71}$, $\frac{31}{73}$, $\frac{31}{78}$, $\frac{33}{26}$, $\frac{34}{5}$, $\frac{34}{28}$, $\frac{35}{1}$, $\frac{35}{2}$, $\frac{35}{4}$, $\frac{35}{7}$, $\frac{35}{8}$, $\frac{35}{38}$, $\frac{36}{4}$, $\frac{37}{3}$, $\frac{37}{5}$, $\frac{37}{6}$, $\frac{37}{7}$, $\frac{37}{8}$, $\frac{37}{13}$, $\frac{37}{14}$, $\frac{37}{27}$, $\frac{38}{3}$, $\frac{40}{7}$, $\frac{41}{23}$, $\frac{40}{4}$, $\frac{40}{5}$.]

Divarication of the lateral toes, 36°; of the inner and middle toe, 22°; of the middle and outer toe, 14°. Length of the inner toe, 4.5 inches; of the middle toe, 5.5 inches; of the outer toe, 5.75 inches; of the foot, 8.2 inches; of the step, 33 inches; of the first phalanx of the inner toe, 2.3 inches; of the second do., 1.5 inches; of the first phalanx, in the middle toe, 1.9 inch; of the second do., 1.6 inch; of the third do., 1.5 inch; of the first in the outer toe, 1.3 inches; of the second in do., 1.2 inches; of the third in do., 1.1 inch; of the fourth in do., 1.4 inch; of the claw of the middle toe, 1 inch. Distance between the tips of the lateral toes, 5.3 inch; do. between the inner and middle toe, 4 inches; do. between the middle and outer toe, 3.7 inches. Projection of the middle toe beyond the lateral ones, 2.7 inches. Angle between the claw of the inner toe and the axis of the toe, 33° (inside); do. on the middle toe, 27° (inside); do. on the outer

toe, 8° (outside); do. between the median line and the axis of the foot, 0° to 5°. Width of the phalanges of the inner and outer toes, 1.2 inch; do. of the middle toe, 1.8 inch. Width of the trackway, 6 inches.

Outline of the track of this species of natural size, shown on Plate XII., fig. 2. It is exhibited, also, on several of the ambrotype sketches on Plates XXXVIII. to LI., as on XXXVIII., figs. 1 and 2, Plate XL., fig. 3, &c. A single track, very perfect, is shown on Plate LVII., fig. 3.

Localities. — It occurs on Mount Holyoke, at Turner's Falls, at the east foot of Mount Tom, and at the Portland quarries. The most interesting locality is the first named, where the track occurs immediately beneath columnar trap, of which there are very few examples yet discovered.

Species 6. Brontozoum Sillimanium.

Ornithoidichnites tuberosus in part, and O. cuneatus in part, of Massachusetts Report, Plate 37, fig. 21, and Plate 38, fig. 22.

Ornithoidichnites Sillimani, Transactions of Association of American Geologists, p. 256.

Bront. Sillimanium of Fossil Footmarks of the United States, p. 171, Plate 3, fig. 2.

[In the Cabinet, Nos. $\frac{1}{1}$, $\frac{1}{3}$, $\frac{1}{5}$, $\frac{2}{5}$, $\frac{3}{1}$, $\frac{4}{1}$, $\frac{5}{14}$, $\frac{9}{10}$, $\frac{9}{14}$, $\frac{10}{1}$, $\frac{10}{8}$, $\frac{13}{4}$, $\frac{14}{4}$, $\frac{16}{1}$, $\frac{16}{5}$, $\frac{16}{6}$, $\frac{16}{8}$, $\frac{17}{3}$, $\frac{19}{9}$, $\frac{19}{10}$, $\frac{20}{1}$, $\frac{20}{2}$, $\frac{20}{6}$, $\frac{20}{11}$, $\frac{21}{1}$, $\frac{22}{13}$, $\frac{22}{51}$, $\frac{24}{1}$, $\frac{26}{18}$, $\frac{26}{22}$, $\frac{27}{16}$, $\frac{31}{16}$, $\frac{32}{2}$, $\frac{32}{4}$, $\frac{32}{42}$, $\frac{34}{4}$, $\frac{34}{7}$, $\frac{37}{4}$, $\frac{37}{10}$, $\frac{38}{1}$, $\frac{38}{2}$, $\frac{41}{7}$, $\frac{41}{15}$, $\frac{41}{16}$, $\frac{41}{17}$, $\frac{41}{19}$, $\frac{41}{24}$.]

Divarication of the lateral toes, 25°; Of the inner and middle toes, 8° to 11°; of the middle and outer toes, 15° to 18°. Length of the inner toe, 2.8 to 3.2 inches; do. of the middle toe, 4 to 4.5 inches; do. of the outer toe, 4 to 5 inches; of the foot, 5.75 to 6.5 inches; of the step, 12 to 20 inches; of the first phalanx of the inner toe, 1 to 1.4 inch; of the second do., 1.1 to 1.2 inch; of the first in the middle toe, 1.1 to 1.4 inch; of the second do., 1.4 inch; of the third do., 1.1 inch; of the claw, 0.8 to 1 inch; of the first in the outer toe, 0.6 to 1.1 inch; of the second do., 0.6 to 0.9 inch; of the third do., 0.7 to 0.8 inch; of the fourth do., 0.8 to 1.2 inch. Distance between the tips of the lateral toes, 3 to 3.5 inches; do. between the inner and middle toes, 2.2 to 3 inches; do. between the middle and outer toes, 2.5 inches. Projection of the middle toe beyond the outer ones, 2 to 2.2 inches. Angle between the claw of the inner toe and the axis of the toe, (inward,) 23°; do between the claw of the middle toe and its axis, 0°; do. between the claw of the outer toe and its axis, 15°, (outward); do. between the median line and the axis of the foot, 0°. Distance of the middle of the heel from the median line, 0 to 1 inch. Width of the phalanges, 0.8 to 1.2 inch. Width of the trackway, 4.5 inches.

An outline of the track of this species is given on Plate XII., fig. 3. Numerous examples on a reduced scale, are given on Plate XXXIII., figs. 4 and 5. These small outlines are more perfect than they are upon the specimens; that is, wherever on the slab I have found a track of this species, although defective in some part, I have made it perfect upon the sketch. Plate XLIII., fig. 6, shows several of these tracks from an ambrotype sketch on a slab from South Hadley. Not a few of them are seen also on Plates XXXIX., fig. 1, XL., fig. 3, XLI., figs. 1 and 2; XLII., figs. 1 and 2; XLV., fig. 5, and especially on Plate LX., fig. 1, which is from Middletown, and is the gem of the Cabinet. The engraving

is intended to be no more perfect than the specimen, which exhibits between fifty and sixty tracks with the phalangeal impressions and claws exceedingly distinct. They are in relief; and were it not for the mud veins, would show the foot of the animal as perfectly as if one lay petrified in each track, or rather projecting from the slab; for the tracks are in relief.

This slab, of slightly reddish micaceous sandstone, has been used as a flagging stone in the streets of Middletown for sixty years. Fifteen or twenty years ago it was taken up, when the tracks were discovered on the under side, and it was secured by Dr. JOSEPH BARRETT, who thus early had become much interested in footmarks, and from him I purchased it for the Ichnological Cabinet. It was dug from the quarry about two miles west of the city, as Dr. BARRETT supposes, nearly eighty years ago; but at present that quarry exhibits no sign of any such tracks, and scarcely of any other.

Upon a review of this species, after it is too late to make any alterations because the Plates are struck off, I regret that I did not place it under Grallator. The discovery of the Grallator formosus makes such a change more desirable. But I will not attempt the change now.

Localities.—This is perhaps the most abundant species among the tracks. It is perhaps most common at South Hadley, Northampton and Portland; but rather common, also, at Turner's Falls. At Portland it accompanies in great numbers the huge Otozoum, as it does at South Hadley.

Remark.—I have found it difficult to define the limits of this species and I apprehend that as now given it embraces at least two species. But I have failed to seize upon any distinctive characters between them. I dedicate this species, as a testimony of respect and gratitude, to my eminent teacher and friend, Professor BENJAMIN SILLIMAN, LL. D., whose long life of devotedness to science, and distinguished success, as well as estimable private character, entitle him to the grateful remembrance of those whom he has taught and encouraged in similar pursuits. I am glad to affix his name to a species the most distinct and common, yet beautiful, in the Cabinet. It is especially due to him, as probably the first scientific man who adopted my views of the footmarks, and whose great work, the American Journal of Science, begun forty years ago, has continued to record the progress of ichnology more than any other work on the globe, for nearly a quarter of a century; that is, from the birth of this branch of science.

Species 7. BRONTOZOUM ISODACTYLUM.

Ornithoidichnites fulicoides.—Transactions Association American Geologists, Plate 11, fig. 4.

Æthiopus minor.—Footmarks of the United States, Plate IV., figs. 2, 3.

[In the Cabinet, Nos. $\frac{16}{2}$, $\frac{26}{10}$, $\frac{16}{5}$, $\frac{16}{3}$, $\frac{21}{4}$, $\frac{31}{86}$, $\frac{33}{10}$, $\frac{35}{4}$, $\frac{35}{37}$, $\frac{37}{27}$, $\frac{37}{22}$, $\frac{41}{21}$, $\frac{41}{34}$, $\frac{6}{3}$, $\frac{22}{5}$, $\frac{17}{2}$, $\frac{22}{12}$, $\frac{28}{2}$, $\frac{35}{31}$, $\frac{35}{40}$, $\frac{39}{2}$? $\frac{40}{6}$.]

Divarication of the lateral toes, 45° to 60°; of the inner and middle toe, 20°; of the middle and outer toe, 28° to 38°. Length of the inner toe, 2.4 to 2.6 inches; of the middle toe, 3 to 3.2 inches; of the outer toe, 2.8 to 3.8 inches; of the foot, 4.2 to 4.5 inches; of the step, 5.5 to 6.5 inches; of the first phalanx of the inner toe, 1 inch;

of the second do., 0.8 to 1 inch; of the first of the middle toe, 0.9 to 1 inch; of the second do., 0.8 to 0.9 inch; of the third do., 0.8 inch; of the claw, 0.6 to 0.8 inch; of the first phalanx of the outer toe, 0.7 inch; second do., 0.6 to 0.7 inch; of the third do., 0.5 to 0.6 inch; of the fourth do., 0.4 to 0.5 inch. Distance between the tips of the lateral toes, 4.4 inches; between the inner and middle toes, 1.9 inch; between the middle and outer toe, 2.3 inches. Projection of the middle toe beyond the lateral ones, 1.2 inch. Angle between the axis of the middle toe and that of the claw, 10°, outward; do. with the inner and outer toes, 0°. Angle between the median line and the axis of the foot, (inward,) 0° to 25°. Distance of the middle of the heel from the median line, 0 to 2 inches. Width of the trackway, 5 inches.

Plate XII., fig. 3, shows an outline of the natural size, of the track of this species. On the ambrotype sketch, Plate XL., fig. 1, are shown not less than four rows of this species, if I mistake not. Plate XLVI., fig. 3, shows two tracks of the same. Plate LVII., fig. 4, represents a single track reduced.

Remark.—This species, although a quite distinct one, is not always easy to be distinguished from certain conditions of Apatichnus circumagens and Plesiornis quadrupes.

Localities.—Turner's Falls is perhaps the best locality. But it occurs at Northampton, South Hadley, and I think, also, at the Portland quarries.

Genus II.—AMBLONYX, (ἀμβλύς, blunt, and ὄνυξ, a claw.)

Æthiopus of the Fossil Footmarks of the United States, Plate 4.

Distinctive Characters, Claws blunt: Phalanges very broad.

Remarks.—I formed the genus Æthiopus (like a coot's foot) under the conviction that certain specimens of tracks showed winged phalanges and claws, like those of the Coot and Grebe. But the more perfect specimens since obtained, lead me to give up the wings of the phalanges, although they have an unusual width. But the great expansion and bluntness, or rather rounded form, of the claws, remains unexplained; and, therefore, I still retain a distinctive name for animals whose tracks have this character. I can conceive of such a state of mud, when trod upon, that the edges of the track should afterwards slide down so as to enlarge the impression; and the same effect might take place in the imprint of the claw, though I should expect in such a case that the ridges between the phalanges would be levelled down. But from specimens in the Cabinet of Amblonyx giganteus, I feel sure that the phalangeal impressions are of the natural size, and yet the claws on these specimens are broader and blunter than in any others. It is hardly credible that the imprint of the claw should be enlarged in the manner suggested, while that of the phalanges was unaffected. I therefore introduce the genus Amblonyx, with two species; not, however, without many doubts whether they may not be identified with Brontozoum tuberatum and exsertum, though differing in other respects besides the claw.

Species 1. AMBLONYX GIGANTEUS. (Nov. Sp.)

[In the Cabinet, $\frac{1}{1}$, $\frac{13}{4}$.]

Divarication of the lateral toes, 30°; of the inner and middle toe, 12°; of the middle and outer toe, 18°. Length of the inner toe, 6 inches; of the middle toe, 7.5 inches; of the outer toe, 9 inches. Distance between the tips of the lateral toes, 7.3 inches; between the inner and middle toes, 5 inches; between the middle and outer toes, 5 inches. Projection of the middle toe beyond the lateral ones, 3.2 inches. Length of the first phalanx of the inner toe, 2.3 inches; breadth of do., 2.8 inches; of the second do., 2.6 inches; breadth of do., 2.4 inches; of the first phalanx of the middle toe, 2 inches; breadth of do., 2.2 inches; of the second phalanx, 2.3 inches; breadth of do., 2.4 inches; of the third phalanx, 2.3 inches; breadth of do., 2.3 inches; of the first phalanx of the outer toe, 2.4 inches; breadth of do., 2.6 inches; of the second phalanx, 1.9 inch; breadth of do., 2.2 inches; of the third phalanx, 1.4 inch; breadth of do., 2.2 inches; of the fourth phalanx, 2 inches; breadth of do., 2.1 inches. Length of the claw of the inner toe, 1.4 inch; breadth of do., 0.9 inch; of the claw of the middle toe, 1.3 inch; breadth of do., 1.4 inch; of the claw of the outer toe, 1 inch; breadth of do., 0.9 inch. Length of the foot, 11.25 inches; of the step, 32 inches. Angle of the axis of the inner toe with that of the claw (inward), 25°; do. of the middle toe (inward), 30°; do. of the outer toe, 0°; do. of the axis of the foot with the median line, 0°. Width of the trackway, 12 inches. Outline track of natural size shown on Plate XIII., fig. 1. On Plate XXXVIII., figs. 1 and 2, are shown several tracks of this species from an ambrotype sketch. They are the largest tracks shown, and are three in number. A single reduced track is shown on Plate LVII., fig. 5.

Locality. — I have met with this species only at Turner's Falls, near the house of ROSWELL FIELD. They were dug out by DEXTER MARSH. The counterpart of Plate XXXVIII., fig. 1, with one more track of this species, is shown on the largest specimen in the Cabinet of the Boston Society of Natural History.

Species 2. AMBLONYX LYELLIANUS.

Æthiopus Lyellianus of Fossil Footmarks.

[Specimens in the Cabinet, Nos. $\frac{1}{1}$, $\frac{1}{2}$, $\frac{13}{4}$, $\frac{31}{84}$, $\frac{31}{85}$.]

Divarication of the lateral toes, 20°; of the inner and middle toe, 10°; of the middle and outer toe, 10°; of the claw on the inner toe and the axis of the toe (inwards), 8°; of the same on the middle toe, 12° inwards; of the same on the outer toe, 20° outward. Length of the inner toe, 4.4 inches; of the middle toe, 5.8 inches; of the outer toe, 5.3 inches; of the foot, 8.2 inches; of the step, 30 inches. Distance from tip to tip of the lateral toes, 4.8 inches; between the inner and middle toes, 3.7 inches; between the middle and outer toes, 3.9 inches. Projection of the middle toe beyond the lateral ones, 3 inches. Length of the first phalanx of the inner toe, 1.8 inch; width of do., 1.4 inch; length of the second phalanx, 1.9 inch; width of do., 1.4 inch; length of the claw, 0.9

inch; width of do., 0.5 inch. Length of the first phalanx of the middle toe, 1.7 inch; width of do., 1.6 inch; length of the second phalanx, 1.7 inch; width of do., 1.7 inch; length of the third phalanx, 1.8 inch; width of do., 1.3 inch; length of the claw, 0.9 inch; width of do., 0.6 inch. Length of first phalanx of the outer toe, 1.2 inch; width of do., 1.2 inch; length of second phalanx, 1.2 inch; width of do., 1.2 inch; length of third phalanx, 0.8 inch; width of do., 1.1 inch; length of fourth phalanx, 1.5 inch; width of do., 1.2 inch; length of the claw, 0.8 inch; width of do., 0.6 inch. Angle of the axis of the foot with the median line, 0° to 10°. Distance of the heel from the median line, one inch. Width of the trackway, 6 inches. Outline track shown of the natural size on Plate XIII., fig. 2. Shown, also, on Plate XXXVIII., fig. 2, from a reduced sketch.

Locality. — I have met with this track only at Turner's Falls, near Mr. Field's house and at the Ferry.

Genus III. — GRALLATOR, (one who goes on stilts.)

Brontozoum in part, of Fossil Footmarks of United States.

Distinctive characters. Stride long; steps nearly on a right line; toes slender.

Remark.—It will be seen that in this genus I have endeavored to embrace the more slender and long-legged varieties of the tridactylous, pachydactylous animals, made known by their footmarks. Such delicate species it seems rather improper to describe as animal giants *(Brontozoum)*. And yet it is no easy matter to separate the Grallator from the Brontozoum. Length of stride and slenderness of toes in most of the species are the only important distinctive characters I can fix upon.

Species 1. Grallator cursorius. (Nov. Sp.)

[Specimens in the Cabinet, Nos. $\frac{3}{1}$, $\frac{4}{1}$, $\frac{10}{6}$, $\frac{23}{2}$, $\frac{33}{44}$, $\frac{35}{9}$, $\frac{35}{12}$, $\frac{35}{13}$, $\frac{21}{1}$.]

Divarication of the outer toes, 26°; of the inner and middle toe, 13°; of the middle and outer toe, 13°; of the claws and axis of the toes, on the inner and middle toes, 0°; of the same on the middle toe, 15° inward; of the axis of the foot with the median line, 0°. Distance of the axis of the foot from the median line, 0. Length of the inner toe, 1.3 inch; of the middle, 2.2 inches; of the outer, 1.7 inch; of the foot, 2.9 inches; of the step, 25 inches. Distance between the tips of the lateral toes, 1.2 inch; between the inner and middle toes, 1.3 inch; between the outer and middle toe, 1.4 inch. Projection of the middle toe beyond the others, 1.2 inch. Length of the first phalanx of the inner toe, 0.6 inch; width of do., 0.3 inch; length of the second phalanx of do., 0.5 inch; width of do., 0.25 inch; length of the first phalanx of the middle toe, 0.7 inches; width of do., 0.4 inch; length of the second phalanx of do., 0.7 inch; width of do., 0.4 inch; length of the third phalanx of do., 0.5 inch; width of do., 0.35 inch. Length of the first phalanx of the outer toe, 0.4 inch; width of do., 0.35 inch; length of the second phalanx of do., 0.3 inch; width of do., 0.3 inch; length of the third phalanx of the outer toe, 0.35 inch; width of do., 0.3 inch; length of the fourth phalanx of the same ,0.45 inch;

width of the same, 0.3 inch. Length of the inner and outer claws, 0.2 inch; of the middle claw, 0.3 inch. Width of the trackway, 2 inches. Outline of the track, showing the natural size, on Plate XIII., fig. 3. It is shown, also, on one or two of the ambrotype sketches, and on the outline sketch, Plate XXXIII., fig. 5; but this species can hardly be distinguished from others on so small a scale. A single track reduced of this species is shown on Plate LVIII., fig. 4.

Localities.—South Hadley furnishes the best examples of this species, in connection with the Otozoum; but it occurs also at Turner's Falls, on Mr. FIELD's farm.

Species 2. GRALLATOR TENUIS. (Nov. Sp.)

[Specimens in the Cabinet, Nos. $\frac{12}{3}$, $\frac{12}{4}$, $\frac{16}{11}$, $\frac{14}{8}$, $\frac{17}{2}$, $\frac{17}{3}$, $\frac{17}{4}$, $\frac{23}{8}$.]

Divarication of the lateral toes, 45°; of the inner and middle toe, 25°; of the middle and outer toe, 28°; of the claws and axes of the toes, 0°. Of the axis of the foot with the median line, 0° to 5°. Distance of the middle of the heel from the median line, 0.25 inch. Length of the inner toe, 1.1 inch; of the middle toe, 2.1 inches; of the outer toe, 1.3 inch; of the foot, 2.7 inches; of the step, 9 inches; of the middle toe beyond the others, 1.5 inch. Distance between the tips of the lateral toes, 1.5 inch; between the inner and middle toes, 1.7 inch; between the middle and outer toes, 1.6 inch. Length of the first phalanx of the inner toe, 0.5 inch; width of do., 0.2 inch; length of the second phalanx of do., 0.4 inch; width of do., 0.2 inch; length of the first phalanx of the middle toe, 0.3 inch; width of do., 0.3 inch; length of the second phalanx of do., 0.4 inch; width of do., 0.3 inch; length of the third phalanx of do., 0.7 inch; width of do., 0.3 inch; length of the first phalanx of the outer toe, 0.3 inch; width of do., 0.25 inch; length of second phalanx of the outer toe, 0.3 inch; width of do., 0.25 inch; length of the third phalanx of the outer toe, 0.2 inch; width of do., 0.25 inch; length of the fourth phalanx of the outer toe, 0.2 inch; width of do., 0.2 inch; length of the claws of the lateral toes, 0.2 inch; of the middle toe, 0.3 inch. Width of the trackway, 2.5 inches.

Outline of the track shown of the natural size, on Plate XIII., fig. 4. Shown, also, on the sketch of volume $\frac{12}{1}$ on Plate LIII., fig. 5.

Localities.—Turner's Falls, below the cataract and close to the trap, where it was discovered by Mr. FIELD; and at South Hadley, where it was discovered by Mr. PLINIUS MOODY.

Remark.—This species differs but little from the G. cursorius save in the much shorter step and greater divarication of the toes.

Species 3. GRALLATOR GRACILLIMUS.

Ornithoidichnites gracillimus.—American Journal of Science, Vol. XLVII., Plate 3, fig. 4.

[Specimens in the Cabinet, Nos. $\frac{16}{10}$, $\frac{16}{3}$, $\frac{16}{14}$, $\frac{19}{3}$, $\frac{19}{4}$, $\frac{19}{5}$, $\frac{21}{4}$, $\frac{31}{6}$, $\frac{32}{45}$, $\frac{32}{18}$, $\frac{41}{22}$, $\frac{41}{18}$, $\frac{37}{18}$.]

Divarication of the lateral toes, 50°; of the inner and middle toes, 28°; of the middle and outer toes, 23°; of the claws and axis of the toes, slight, the claws turned inward; of the axis of the foot with the median line, 0° to 10°. Distance of the middle

of the heel from the median line, 0.5 inch. Length of the inner toe, 1.55 inch; of the middle toe, 2 inches; of the outer toe, 1.8 inch; of the foot, 2.5 inches; of the step, 7 to 8 inches; of the middle toe beyond the others, 0.8 inch. Distance between the tips of the lateral toes, 2.1 inches; between the inner and middle toe, 1.4 inch; between the middle and outer toe, 1.4 inch. Length of the first phalanx of the inner toe, 0.6 inch; width of do., 0.5 inch; length of the second phalanx, 0.5 inch; width of do., 0.4 inch; length of the inner claw, 0.3 inch; of the first phalanx of the middle toe, 0.7 inch; width of do., 0.5 inch; length of the second phalanx, 0.5 inch; width of do., 0.35 inch; length of the third phalanx, 0.4 inch; width of do., 0.3 inch; length of the claw, 0.4 inch; length of the first phalanx of the outer toe, 0.45 inch; width of do., 0.4 inch; length of the second phalanx, 0.45; width of do., 0.4 inch; length of the third phalanx, 0.35 inch; width of do., 0.3 inch; length of the fourth phalanx, 0.3 inch; width of do., 0.3 inch; length of the claw, 0.25 inches. Width of the trackway, 3 5 inches.

The tracks of the natural size shown on Plate XIII., fig. 5. On Plate XXXIX., fig. 2, is shown an ambrotype sketch of a slab of this species, with rain drops.

Localities.—Turner's Falls at the Ferry is the principal locality, though I have seen it at South Hadley and perhaps at Portland.

Species 4. Grallator cuneatus. (Nov. Sp.)

Ornithoidichnites cuneatus, *Barratt*, in part, perhaps. See Massachusetts Geological Report, p. 488.

[Specimens in the Cabinet, Nos. $\frac{1}{3}$, $\frac{1}{5}$, $\frac{5}{9}$, $\frac{9}{11}$, $\frac{10}{1}$, $\frac{14}{1}$, $\frac{14}{7}$, $\frac{14}{4}$, $\frac{13}{5}$, $\frac{16}{1}$, $\frac{17}{1}$, $\frac{20}{3}$, $\frac{20}{6}$, $\frac{21}{1}$, $\frac{29}{1}$, $\frac{30}{1}$, $\frac{30}{2}$, $\frac{31}{15}$, $\frac{25}{1}$, $\frac{25}{2}$, $\frac{31}{3}$, $\frac{32}{43}$, $\frac{35}{11}$, $\frac{35}{3}$, $\frac{41}{38}$, $\frac{34}{8}$, $\frac{34}{41}$, $\frac{16}{4}$, $\frac{16}{5}$, $\frac{16}{11}$, $\frac{16}{6}$, $\frac{20}{10}$, $\frac{20}{7}$.]

Divarication of the lateral toes, 28° to 45°; of the inner and middle toe on a specimen with the smallest spread, 12°; of the middle and outer toes, 16°; of the claws of the lateral toes with the axes of the toes, 30° to 40°, outwards; of the claw of the middle toe, 0°; of the axis of the foot with the median line, 0°. Distance of the middle of the heel from the median line, 0.5 inch. Length of the inner toe, 2.2 to 2.4 inches; of the middle toe, 3.4 to 3.7 inches; of the outer toe, 3 to 3.1 inches; of the foot, 4.9 to 5 inches; of the step, 22 to 24 inches; of the middle toe beyond the lateral ones, 2 to 2.2 inches. Distance between the tips of the lateral toes, 2.9 inches; between the inner and middle toe, 2.5 to 2.7 inches; between the middle and outer toes, 2.3 to 2.7 inches. Length of the first phalanx of the inner toe, 0.85 inch; width of do., 0.6 inch; length of the second phalanx of do., 0.85 inch; width of do., 0.5 inch; length of the claw of do., 0.6 inch. Length of the first phalanx of the middle toe, 1.0 inch; width of do., 0.6 inch; length of the second phalanx, 0.85 inch; width of do., 0.6 inch; length of the third phalanx, 0.85 inch; width of do., 0.6 inch; length of the claw, 0.7 inch; length of the first phalanx of the outer toe, 0.6 inch; width of do., 0.55 inch; length of the second phalanx, 0.7 inch; width of do., 0.5 inch; length of the third phalanx, 0.6 inch; width of do., 0.5 inch; length of the fourth phalanx, 0.7 inch; width of do., 0.45 inch; length of the claw, 0.6 inch; width of the trackway, 3.5 inches.

Track shown of the natural size on Plate XIII., fig. 6. Also on Plate XXXIX., fig. 1, is shown a multitude of impressions of this species. These tracks are shown also on fig. 3 of the same Plate; also on Plate XLI., figs. 1 and 2, and Plate XLII., figs. 1, 2 and 3.

Localities.—South Hadley, north part, and Turner's Falls; a quite common species.

This species is distinguished from Brontozoum Sillimanium by its more slender proportions and greater extension of the middle toe, beyond the others, as well as greater divarication of the lateral toes, which give it the shape of a wedge. The claws, likewise, are more uniformly bent outward on the lateral toes, and at a greater angle. I confess, however, that it is not always easy to distinguish between these several species; or rather, I find specimens that are intermediate.

Remark.—Although I had often observed the tracks of the following beautiful species in the Cabinet, and could not bring them within the limits of any other, it was not till even all the Plates of this Report had been struck off, that I made up my mind to describe it as a distinct species. But on taking and comparing its measurements they seemed to me too distinct from others to be neglected; and therefore, by the aid of a wood-cut, I introduce it.

Species 5. Grallator formosus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{3}{1}$, $\frac{25}{1}$, $\frac{26}{18}$, $\frac{2}{6}$, $\frac{32}{43}$, $\frac{35}{31}$, $\frac{39}{2}$, $\frac{38}{1}$, $\frac{41}{15}$.]

Divarication of the lateral toes, 50° to 55°; of the middle and inner toe, 20°; of the middle and outer toe, 32°. The claw of the outer toe diverges 25° from the axis of the toe outward; and that of the inner toe about as much inward; of the middle toe, also, about the same inward; of the axis of the foot from the median line, 4°. Width of the trackway, 6 inches. Length of the inner toe, 3.9 inches; of the middle toe, 5 inches; of the outer toe, 4.4 inches; of the foot, 6.8 to 7.3 inches; of the step, 27 inches; of the middle toe beyond the others, 3 inches. Distance between the tips of the lateral toes, 4.4 inches; between the inner and middle toe, 3.3 inches; between the middle and outer toe, 4.1 inches. Length of the first phalanx of the inner toe, 1.1 inch; of the second, 1.2 inch; of the claw, 0.5 inch; width of the phalanges of the inner toe, 0.9 inch. Length of the first phalanx of the second toe, 1.5 inch; of the second phalanx, 1.4 inch; of the third, 1.5 inch; of the claw, 0.8 inch. Width of the phalanges of the middle toe, 1.2 inch. Length of the first phalanx of the outer toe, 1 inch; of the second do., 0.9 inch; of the third, 0.8 inch; of the fourth, 1 inch; of the claw, 0.6 inch. Width of the phalanges of the outer toe, 0.8 inch. Middle toe extends beyond the others, 3 inches. On some specimens the double-headed termination of the bone to which the toes are articulated leaves an impression on the track an inch long and about 0.8 inch wide.

The outline of the track of this species is shown on the subjoined wood-cut, fig. 1. This has not on it the impression of the heel bone just mentioned, nor is it exhibited so distinctly upon any specimen which I am sure belongs to this species, as it is upon some which I have been in the habit of referring to Brontozoum Sillimanium. I have therefore shown it on wood-cut fig. 2. I find at least upon two tracks on the specimen from

which fig. 2 was copied and which came from South Hadley, (No. $\frac{26}{18}$,) that there are three impressions as shown on the track, made not improbably by the three articulating surfaces of the tarso-metatarsal bone for the toes. Their position is not opposed to, but rather favors, such a supposition. This fact is so important that it ought to have been shown upon the regular Plates; but having been accidentally omitted there, it is added here. Several examples of one or more impressions of these heel bones are exhibited on the beautiful specimen from Middletown, delineated on Plate LX., fig. 1.

The tracks of this species are shown on the ambrotype sketch, Plate XXXIX., fig. 1; but on so small a scale that it will hardly be distinguished from G. cuneatus.

Localities.—On the red shale of Wethersfield and the harder shale of Turner's Falls, at Lily Pond.

Affinities of the Group.

The alternation of right and left feet, proves the animals to have been bipeds. The number and position of the toes ally them to certain kinds of birds, namely, the Scansores and Grallatores. The first order embraces the ostrich tribe; namely, the African Ostrich, the Cassowary, or New Holland Ostrich, and the Rhea, or South American Ostrich, as well as the extinct species of Æpiornis, Dinornis, and Palapteryx of Madagascar and New Zealand. It is to these fossil species that the Brontozoum and Amblonyx seem most nearly related. In order to show this, I give a representation, of a small size, of the foot of Palapteryx ingens, as figured by the late Gideon Mantell, from a very perfect specimen.[12] See Plate VI., fig. 3. The ungual phalanx in this specimen looks much like a claw, and, indeed, we can sometimes determine with difficulty where the claw ends and the bone begins. At any rate, when the two outer phalanges were bound together by ligaments and covered by integuments, they and the claw would make only two impressions, namely, that of a phalanx and of a claw.

Hence the whole track of the Palapteryx would exhibit two phalanges on the inner toe, three on the middle and four on the outer, each terminated by a claw. And this is a general law as to the feet of living birds. Those which have a fourth toe inside, show on that toe only one phalanx besides the ungual and a claw.

Now the feet of this first Group of footmarks correspond exactly as to the phalanges and claws with those of living birds, as may be seen in the drawings, and in the cabinet. The impression is exactly such as would be made by a foot of the Palapteryx. This, as already shown, would not show an ungual phalanx distinct from the claw, neither do the fossil footmarks. Many of the fossil impressions, however, seem to me more distinct and rounded in the phalanges than the foot of the Palapteryx would make, when clothed with flesh. I have a plaster mould of the track of the Rhea, or South American Ostrich, presented by Professor Jeffries Wyman, and shown on Plate LV., fig. 1; but the phalanges

[12] A perfect specimen of the foot and tarso-metatarsal bone may be seen in the cabinet of the Academy of Natural Sciences in Philadelphia: and a similar one, though deficient in three phalanges (whose places are supplied by wood,) is suspended from the ceiling in the Appleton Ichnological Cabinet.

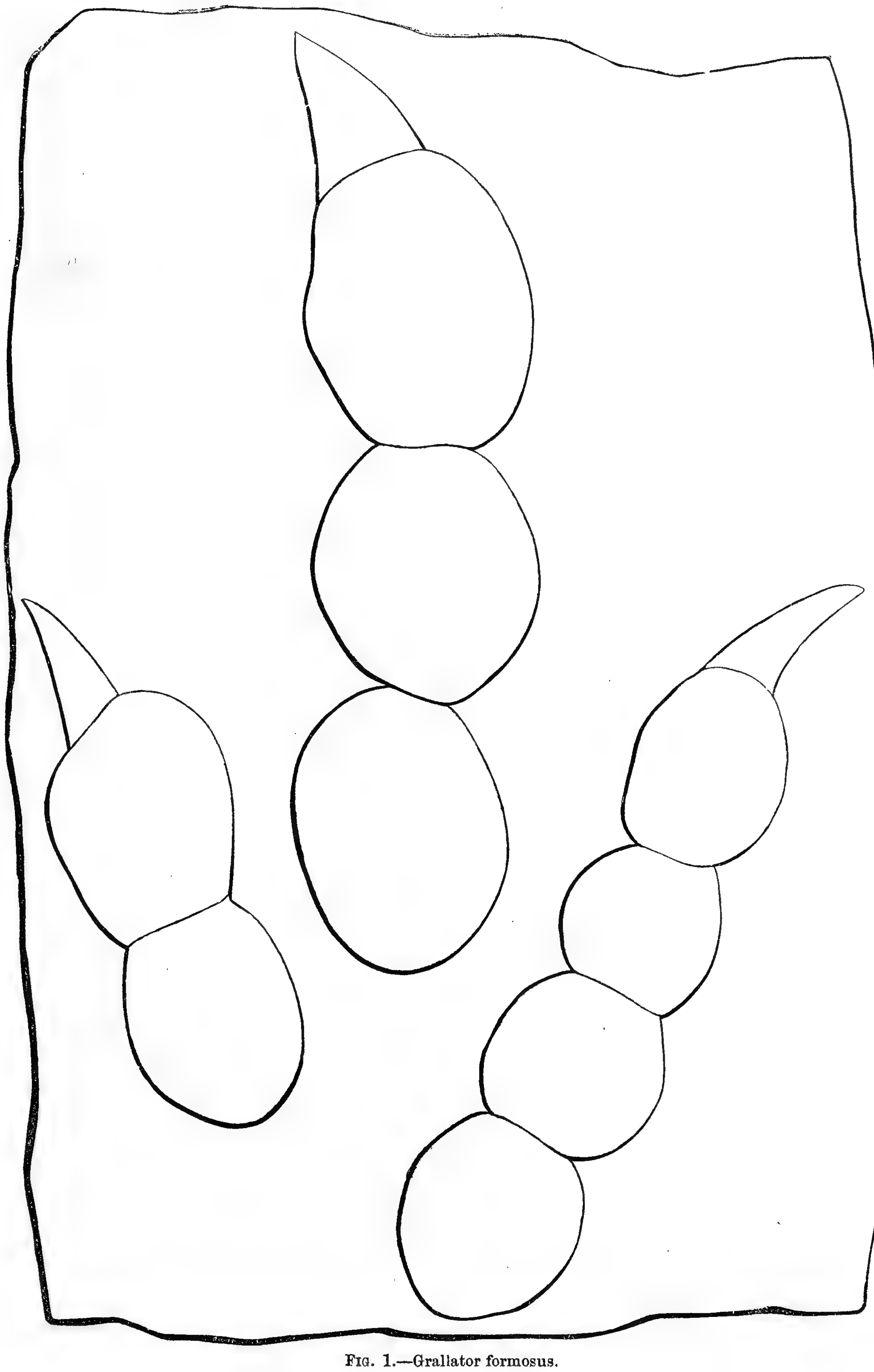


Fig. 1.—Grallator formosus.

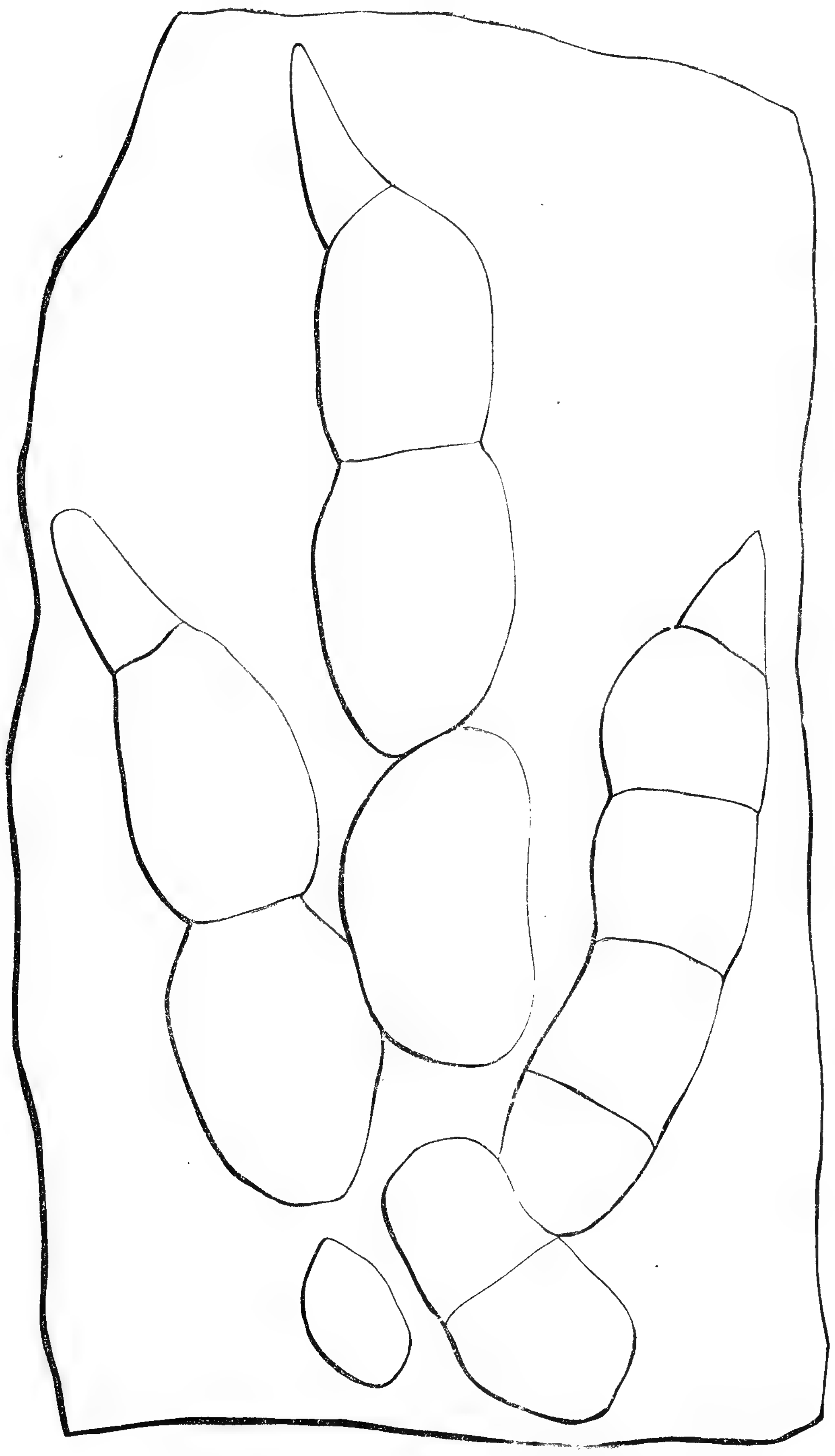


Fig. 2.—Brontozoum Sillimanium, with heel bones.

are far less distinct upon it than upon the fossil footmarks, although the claw corresponds almost exactly to that of Brontozoum validum. What peculiarity there may have been in the fossil animals, which has made their tracks even more distinct in this respect than those of living animals of similar type, I know not. But every comparative anatomist must regard the facts I have stated as very strong evidence that the former must have been birds. That the peculiarities of those early animals were so great that the well known law, as to the number of phalanges, was different then from what it now is, will hardly be admitted by any one familiar with the laws of correlation among animals. If indeed it were certain that the hind foot of the Anomœpus, which we know to have been a quadruped, had the same number of phalanges as a bird, it would seem at first to weaken somewhat the force of this argument. Yet it would be more reasonable to admit my explanation of such a fact to be given in the next paragraph, than that this great law as to the number of phalanges in the feet of birds was not true in sandstone days. If it were true the conviction becomes quite strong that the animals of this group were birds allied to those of the Dinoris and living Struthionidæ or ostrich tribe. Nor, since the discovery of the giant extinct birds of Australia, and the admission that these fossils of the Connecticut Valley probably belong to the Jurassic series, will geologists be very unwilling to admit such a conclusion.[13]

In all our reasoning as to the animals of this Group and those of the Anomœpus from the number of phalanges, we must not forget certain facts respecting the phalanges of the Loricoid and Saurian Lizards. If it be true that the ungual phalanx in birds, such as the Ostrich and Palapteryx, is so connected with the claw, that in a track only the impression of a claw will be made, then we must subtract one from the number of phalangeal impressions which theory would lead us to suppose their toes would leave in a track. And such would certainly be true in such a foot as that of the Palapteryx, and also, I think, in all thick-toed living birds; and such is the number in the fossil footmarks. Now in all the Loricoid and Saurian Lizards the number of phalanges in the four inner toes, is 2, 3, 4, 5; corresponding to the number of phalangeal impressions on the fossil footmarks of the second Group, if we leave out the inner toe, which is not found in the latter. Suppose now, that the five hind toes of a lizard were consolidated into three; we might reasonably expect that the number of phalanges in those three toes would be the same as in the three original middle toes: or suppose that the inner and outer toes were omitted, the same result would follow; and we should have in these three remaining toes, the same number of phalanges as in the three outer toes of birds; and since the fossil footmarks, for a reason already given, show one less than the true number of phalangeal

[13] In the Annual of Scientific Discovery for 1858, p. 375, it is stated, that at a meeting of the Boston Society of Natural History, I represented it as "doubtful if the tracks which I had supposed to have been made by birds in the Connecticut Valley Sandstone, were really produced by birds, since one great argument, namely, that of the number of phalanges in the toe, is lost." In answering a playful remark of Prof. H. D. Rogers, at a meeting of that Society, I intended merely to express an apprehension that should it turn out that the Anomœpus has the same number of phalanges as birds, it might weaken the argument for the ornithic origin of the fossil footmarks; but never intended to say that I had given it up; and since I have learnt how a three-toed lizard might show the same number of phalanges as a bird, I hardly feel that this argument is shaken at all. I am sorry if I was understood by the Society to give up the Jurassic birds.

impressions, their number, also, might correspond in the group under consideration with those in the three middle toes of lizards. Such a fact might furnish a rather strong presumptive argument in favor of the lizard character of the Anomœpus; but it would not show that the bipedal tridactyle animals of this Group were not birds.[14]

It may be thought that if the law as to the number of toes on an animal may be changed, as we know it can be, that as to the number of phalanges may be equally variable But I fancy that to leave out or to add a toe, would infringe much less upon the laws of relation and harmony than to do the same with the phalanges. But I submit this question to the comparative anatomist.

The species of Grallator above described, I should refer to the Grallatores, on the ground that their slenderness of feet better compares with those of the Grallæ than with those of the Cursores: for though stouter, perhaps, than those of most living Grallæ, their size, relative to congeneric races, was not greater. Secondly, on account of their long stride for the most part, and near coincidence between the axis of the foot and the line of direction, showing great length of leg.

It ought, moreover, to be added, that the Grallæ above all other birds, might be expected to frequent the muddy shores of the estuary or lake where doubtless the fossil footmarks were formed. We ought not to expect to find in such a place the tracks of many other species of birds. Hence a suspicion may arise that the species of Brontozoum might belong to the Grallæ, though the Cursores are closely allied.

GROUP III.—LEPTODACTYLOUS OR NARROW-TOED BIRDS.

Remarks.—This Group embraces two sections: first, the three-toed animals; secondly, the four-toed. The distinction between them would, perhaps, be sufficient to justify us in forming two separate groups, could we be certain from the tracks which species have only three toes. But large experience has satisfied me that this is a point on which we cannot be sure; because the hind toe usually makes so much slighter an impression than the others, that it is preserved only occasionally, and sometimes we do not discover the existence of the inner toe for years, as has been the case with the Platypterna ingens and elegans, to be described under this Group, and now first removed from the three-toed to the four-toed section; and that, too, on evidence derived from a more careful cleavage of the specimens.

[14] To show the interest attached to this subject, I quote a few sentences from the most eminent of European comparative anatomists, Professor Richard Owen, of London, as given in the Proceedings of the London Geological Society for February 20th, 1856, p. 204.

"Perhaps," says Owen, "no part of the progress of Paleontology, since the demise, in 1832, of the founder of that science, has been more striking and unexpected, than that which relates to the discovery and restoration of giant members of the feathered Class."

"First indicated by the foot prints in the new Red Sandstones of the Valley of the Connecticut, described by Hitchcock in 1836; next demonstrated by the evidence of the bones themselves from the recent deposits in New Zealand, in 1839 and 1843; afterwards exemplified by the great eggs and associated fragments of skeleton discovered in alluvial banks of streams in Madagascar, in 1851; the list of extinct giant birds has lately been recruited by the fossil remains of a species, at least as large as an ostrich, from the Eocene conglomerate at Meudon, near Paris, which lies between the plastic clay and the surface of the chalk."

Indeed, I have no great confidence that all the species described below as tridactylous, may not in like manner be ere long transferred to the tetradactylous species. This is not, however, a matter of great importance, since such a transfer would not make it necessary to change the name of the animal; nor, if both sections be birds, as I shall suggest, would it alter their affinities essentially, but merely the number of their toes.

Some have objected to the distinction which I have made between the pachydactylous, or thick-toed animals, such as we have described, and the leptodactylous or narrow-toed, on the ground that the latter have all been formed from the former, by the manner in which the animal trod upon the mud. If its condition was such that the foot sunk deep as the toes were withdrawn, the mud would collapse and leave only a narrow imprint devoid of phalangeal impressions. I have no doubt that such has sometimes been the case, as is proved by specimens in the Cabinet, the most striking of which is No. $\frac{41}{21}$. But in this case, though the lowest layer impressed is considerably broader than that two and a half inches above, it does not show phalanges though the claw is obvious on one toe at least. Yet we know that this distinction of narrow-toed and thick-toed species exists among living animals, and we should therefore expect it among the extinct ones. And, moreover, we do find both varieties on the same slab, of which Nos. $\frac{6}{1}$, $\frac{9}{10}$, $\frac{10}{6}$, $\frac{22}{1}$, $\frac{25}{1}$, in the Cabinet, are examples. Judging from the slabs, however, I think we should infer a larger number of pachydactylous than leptodactylous animals to have made the tracks.

I.—TRIDACTYLOUS.

Genus I.—ARGOZOUM. (From Ἄργης, a giant, and ζῶον, an animal.)

Leptodactylous, tridigitate. Toes curved, the lateral ones more or less outward; curved upward, also, behind, so as to be keel-shaped. Mostly digitigrade and rarely showing a heel.

Species 1. Argozoum Redfieldianum.

Ornithoidichnites Redfieldii, American Journal of Science, Vol. XLVII., Plate 3, fig. 1.

[In the Cabinet, Nos. $\frac{14}{2}$, $\frac{14}{3}$, $\frac{14}{9}$.]

Divarication of the lateral toes, 75°; of the inner and middle toe, 30°; of the middle and outer toe, 45°; of the axis of the foot and the median line, 0° to 10°. Length of the middle toe, 12 inches; of the inner toe, 8 inches; of the outer toe, 9.5 inches; of the claw, 2 inches; of the foot, 12.5 inches; of the step, 30 inches. Distance between the tips of the lateral toes, 12 inches; between the inner and middle toe, 7.8 inches; between the middle and outer toe, 9 inches. Projection of the middle toe beyond the other, 6 inches. Versed sine of the inward curvature of the middle toe, 0.7 inch. Fossil coprolite, 1.75 inch long, one inch wide. Calcigrade, that is, the hind part of the foot, makes a deeper impression than the toes. Width of the trackway, 13 inches. Track shown of the natural size on Plate XIV., fig. 1.

Locality.—Chicopee Falls is the only place where I am sure I have found the track of this species. The hard quartz, or slightly calcareous, gray sandstone of that place, directly in the bottom of the river, a little above the bridge, furnished my specimens.

Remarks.—This is the only one of the leptodactylous species whose track exhibits a claw distinguishable from the toe, and the only one with which coprolites are so associated as to make it almost certain they can be referred to it. Their analysis will be given in summing up the characters of the group. The species is dedicated to my friend, the late William C. Redfield.

Species 2. Argozoum dispari-digitatum.

Ornithoidichnites macrodactylus of Massachusetts Geological Report, Plate 43, fig. 35.

Argozoum dispari-digitatum. Fossil Footmarks of the United States, Plate VI., fig. 2.

[In the Cabinet, Nos. $\frac{13}{3}$, $\frac{23}{5}$, $\frac{37}{16}$, $\frac{37}{17}$, $\frac{37}{20}$, $\frac{37}{19}$, $\frac{32}{7}$, $\frac{41}{46}$, $\frac{35}{39}$.]

Divarication of the lateral toes, 40° to 55°; of the inner and middle toe, 18° to 30°; of the middle and outer toes, 20° to 25°; of the axis of the foot with the median line, 0°. Length of the inner toe, 3 inches; of the middle toe, 5 inches; of the outer toe, 3.5 inches; of the foot, 5.5 inches; of the step, 15 inches. Distance between the tips of the lateral toes, 3 inches; between the inner and middle toe, 3 inches; between the middle and outer toe, 2.75 inches. Projection of the middle toe beyond the others, 2.25 inches. Distance of the heel from the median line, 0.6 inch. Plantigrade. Width of the trackway, 4 inches. Track shown of the natural size on Plate XIV., fig. 2.

Localities.—Wethersfield, Chicopee Falls, and Lily Pond, Gill.

Species 3. Argozoum pari-digitatum.

Ornithichnites minimus, American Journal of Science, Vol. XXIX., p. 325.

Ornithichnites isodactylus. Massachusetts Geological Report, Plate 45, figs. 38, 39.

Argozoum pari-digitatum of Fossil Footmarks of the United States, Plate VI., figs. 3 and 4.

[Nos. in the Cabinet, $\frac{9}{5}$, $\frac{21}{7}$, $\frac{25}{1}$, $\frac{33}{1}$, $\frac{40}{7}$, $\frac{41}{37}$, $\frac{31}{10}$, $\frac{31}{12}$, $\frac{32}{30}$, $\frac{33}{4}$, $\frac{33}{10}$.]

Divarication of the lateral toes, 80° to 100°; of the inner and middle toe, 40° to 50°; of the middle and outer toe, 40° to 50°; of the axis of the foot with the median line, 0° to 30°. Distance of the centre of the heel from the median line, 0 to 1 inch. Length of the inner toe, 0.9 inch; of the middle toe, 1.3 inch; of the outer toe, 1 inch; of the foot, 1.6 inch; of the step, 6 inches; of the middle toe beyond the others, 0.9 inch. Distance between the tips of the lateral toes, 1.7 inch; between the inner and middle toes, 1.1 inch; between the middle and outer toes, 1.4 inch. Lateral toes curved outward, the middle one inward. Width of the trackway, 1.7 inch. Track shown of the natural size, on Plate XIV., fig. 3; also a row of eight tracks on Plate XXXV., fig. 4; and another row on Plate XXXIX., fig. 1.

Localities.—Gill, Horse Race and Lily Pond, and at Wethersfield.

Genus II.—PLATYPTERNA. (From πλατύς, broad, and πτέρνα, a heel.)

Heel broad; foot plantigrade, and often calcigrade. Toes very narrow, and curved both vertically and horizontally.

Remark.—The breadth of the heel is the most important distinction between this genus and the Argozoum. Yet some of the tracks when cleaved, approach so near that genus, as well as the Ornithopus, (which has four toes,) that it would not be strange if future researches should unite them. But my descriptions must be founded on present knowledge.

Species 1. Platypterna Deaniana.

Ornithoidichnites Deani of Massachusetts. Geological Report, Plate 42, figs. 31, 32; and Plate 44, fig. 37.

Platypterna Deaniana of Fossil Footmarks of the United States, Plate VII., fig. 1.

[In the Cabinet, Nos. $\frac{32}{23}$, $\frac{32}{24}$, $\frac{32}{29}$, $\frac{32}{26}$, $\frac{27}{2}$, $\frac{37}{26}$.]

Divarication of the lateral toes, 60° to 70°; of the inner and middle toe, 40° to 45°; of the middle and outer toe, 25° to 30°; of the axis of the foot with the median line, 10°. Length of the inner toe, 1.5 inch; of the middle toe, 3 inches; of the outer toe, 2 inches; of the heel, 1.1 to 1.2 inch; of the foot, 4 to 4.5 inches; of the step, 9 to 12 inches; of the middle toe beyond the rest, 1.8 inch. Width of the heel, 0.9 inch. Distance between the tips of the lateral toes, 2 to 2.5 inches; between the inner and middle toe, 2 to 2.2 inches; between the middle and outer toe, 2 to 2.3 inches. Versed sine of the curvature of the inner toe, inwards, 0.17 inch; of the middle toe, inwards, 0.12 inch; of the outer toe, outwards, 0.22 inch. Foot plantigrade, and often strongly calcigrade; toes somewhat keel-shaped, very narrow. Width of the trackway, 3 inches (?).

Track shown of the natural size on Plate XIV., fig. 4.

Locality.—On the fine red shale of Wethersfield Cove, where alone I have found this species.

Remark.—The tracks of this species have furnished two of the best specimens I have ever seen, of the recession of the impressions on the successive layers of shale as we go upward. This will be best understood by looking at Plate VI., fig. 2. It is satisfactorily explained by supposing the surface on which the animal trod to have been inclined; and we find accordingly, that the heel made a much deeper impression than the toes (calcigrade). But I have so fully treated of this point in the preliminary principles, that I need not here enlarge.

This species is dedicated to the late Dr. James Deane, who first called my attention to the subject of footmarks, and who has subsequently investigated it with much success, as its Bibliography, prefixed to this Report, will show.

Species 2. Platypterna tenuis.

Ornithoidichnites tenuis. Massachusetts Geological Report, Plate 43, figs. 33, 34.

Platypterna tenuis. Fossil Footmarks of the United States, Plate VII., figs. 2 and 3.

[In the Cabinet, Nos. $\frac{31}{7}$, $\frac{31}{79}$, $\frac{32}{38}$, $\frac{32}{39}$, $\frac{32}{40}$, $\frac{35}{44}$.

Divarication of the lateral toes, 45° to 60°; of the inner and middle toe, 20° to 30°; of the middle and outer toe, 25° to 30°. Length of the inner toe, 1 inch; of the middle toe, 2 inches; of the outer toe, 1.3 inch; of the heel, so far as it reached the ground, 0.6 inch; of the foot, 2.1 inches; of the step, 7 inches. Width of the heel, 0.6 inch. Distance between the tips of the lateral toes, 1.1 to 1.7 inch; between the inner and middle toe, 1.1 to 1.4 inch. Length of the middle toe beyond the others, 0.9 to 1.1 inch. Foot plantigrade, inclining to digitigrade; toes very slender; lateral ones curved outwards. Width of the trackway, 2 inches (?).

Track shown of the natural size on Plate XIV., fig. 5. An ambrotype sketch of a single track is also shown on Plate LVIII., fig. 10.

Locality.—On the red shale at Wethersfield Cove.

Species 3. Platypterna delicatula.

Ornithoidichnites delicatulus of Massachusetts Geological Report, Plate 45, fig. 40.

Platypterna delicatula. Fossil Footmarks of the United States, Plate VII., fig. 4.

[In the Cabinet, $\frac{31}{11}$, $\frac{31}{11}$ (bis).]

Divarication of the lateral toes, 40°; of the inner and middle toes, 22°; of the middle and outer toe, 18°. Length of the inner toe, 0.65 inch; of the middle toe, 1.1 inch; of the outer toe, 0.75 inch; of the heel, 0.4; breadth of the same, 0.3 inch; length of the foot, 1.5 inch; of the step, 3 inches; of the middle toe beyond the rest, 0.5 inch. Distance between the tips of the lateral toes, 0.6 inch; between the inner and middle toe, 0.6 inch; between the middle and outer toe, 0.55 inch. Foot plantigrade, or even calcigrade. Width of the trackway, 2 inches.

Track shown of the natural size on Plate XIV., fig. 6. An ambrotype sketch of a single track is shown on Plate LVIII., fig. 8.

Locality.—The red shale of Wethersfield Cove.

Species 4. Platypterna recta.

Harpedactylus rectus. Fossil Footmarks of the United States, Plate V., fig. 5, and XXIV., fig. 7.

[In the Cabinet, $\frac{6}{2}$.]

Divarication of the lateral toes, 36°; of the inner and middle toe, 10°; of the middle and outer toe, 27°; of the axis of the foot with the median line, 5° to 10° inward. Length of the inner toe which reached the ground as the animal walked, 2.5 inches; do. to where the three toes intersect backward, 3.5 inches. Length of the middle toe impressing

the ground, 3.75 inches; do. whole toe, 5 inches. Length of the outer toe impressing the ground, 2.5 inches; do. whole toe, 4.1 inches; of the foot impressing the ground, 3.75 inches; of the step, 5.5 inches; of the middle toe beyond the rest, 1.4 inch. Distance between the tips of the lateral toes, 2.5 inches; between the inner and middle toe, 1.6 inch; between the middle and outer toe, 2 inches; between the rows of tracks made by the right and left foot, 3.5 inches; hence the distance of each row from the median line, 1.75 inch.

Foot digitigrade, its width behind where the toes ceased to make an impression in walking, 2 inches Toes very straight and narrow. Width of the trackway, 5.5 inches.

Track shown of the natural size on Plate XIV., fig. 7. Also the whole row on the only slab in the Cabinet, on Plate XLVII., fig. 3.

Locality.—Turner's Falls, at the ferry, on the Gill shore, on fine gray micaceous sandstone, dipping south-easterly at an angle of 40°.

Remarks.—I am of opinion that this species of animal must have belonged to a different genus from the other species of Platypterna. Had the whole foot and heel made an impression, it would probably have been easy to make out distinctive genuine characters. But the only tracks which we possess might have been a digitigrade imprint of a species of Platypterna. Yet the unexampled shortness of the step for so large a foot, and the great width between the rows of tracks, give us an idea of a thick, short-legged, clumsy animal, different from the slenderer and perhaps elegant forms of the other species of Platypterna. I think it best, however, to leave this species provisionally in that genus.

Species 5. Platypterna varica.

Harpedactylus concameratus of Footmarks of the United States, Plate XIV., fig. 3.

[In the Cabinet, Nos. $\frac{5}{11}$, $\frac{10}{6}$, $\frac{11}{1}$, $\frac{11}{3}$, $\frac{11}{5}$, $\frac{14}{2}$, $\frac{23}{6}$, $\frac{34}{3}$, $\frac{35}{14}$, $\frac{35}{15}$, $\frac{35}{16}$, $\frac{6}{1}$, $\frac{27}{4}$, $\frac{16}{4}$, $\frac{35}{18}$.]

Divarication of the lateral toes, 75°; of the inner and middle toe, 23°; of the middle and outer toe, 52°; of the axis of the foot from the median line, the foot turning inward, 20°. Distance of the middle of the heel from the median line, 5 inches. Length of the inner toe (measured on the chord) from the middle of the heel, 3 inches; of the middle toe, 3.6 inches; of the outer toe, 2 inches; of the heel, 1.1 inch; width of do., 2 inches; length of the foot, 5 inches; of the middle toe beyond the rest, 2 inches; of the step, 8 to 12 inches. Versed sine of curvature in the inner toe, 0.3 inch; in the middle toe, 0.4 inch; in the outer toe, 0.15 inch. Distance between the tips of the lateral toes, 3.7 inches; between the inner and middle toe, 1.5 inch; between the middle and outer toe, 3.3 inches. Foot vaulted so as to make an elevation on the reversed tracks quite prominent, and nearly an inch wide, between the heel and the place where the toes reach the ground. Width of the trackway, 11 inches.

Outline of a very perfect specimen of the track, shown on Plate XIV., fig. 8. A row of these tracks is also shown on Plate XLVII., fig. 4.

Remark.—This species is remarkable for the great width of the heel, the inward curvature of the toes, the vaulted character of the foot, and the width between its feet as

it walked; so that the track appears like that of a goose. The specific name (*varica*, one that straddles) is derived from this last character.

Locality.— Turner's Falls, at the Ferry, discovered by Mr. Marsh.

Species 6. Platypterna digitigrada. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{16}$, $\frac{16}{4}$, $\frac{21}{1}$.]

Divarication of the lateral toes, 80°; of the inner and middle toe, 43°; of the middle and outer toe, 37°. Inclination of the axis of the foot towards the median line, 10° to 20°. Distance of the posterior extremity of that axis from the median line, 0.6 inch. Versed sine of curvature in the inner toe, 0.1 inch; do. in the middle toe, 0.15 inch; outer toe straight. Length of the inner toe, 1.2 inch; of the middle toe, 1.5 inch; of the outer toe, 1.2 inch; of the heel, indefinite on the track; width of the heel, 0.8 inch; foot strongly digitigrade. Toes thick, with claws a quarter of an inch long. Length of the step, 4 to 4.5 inches. Of the middle toe beyond the rest, 0.6 inch. Distance between the tips of the lateral toes, 1.6 inch; do. between the inner and middle toe, 1 inch; between the middle and outer toe, 1 inch. Width of the trackway, 3 inches.

Outline of the track shown of the natural size, on Plate XIV., fig. 9. Also a row of tracks on Plate LI., fig. 2.

Locality.— Turner's Falls, on Mr. Field's farm, from whom I purchased the specimens in the Cabinet.

I was at first inclined to refer this species to the P. varica; but its smallness and strongly digitigrade character, with the distinctness of its claws, justify a separation. I should not be surprised, however, if some or all of the species of Argozoum and Platypterna should be found to be four-toed, and possibly some of them four-footed, and so identical with species described under other genera; the P. Deaniana, for instance, with Ornithopus gallinaceus, to be described. But till additional facts are brought to light, the above arrangement is the best I can make.

Species 7. Platypterna gracillima. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{39}{4}$, $\frac{39}{5}$, $\frac{35}{33}$, $\frac{35}{46}$, $\frac{35}{44}$, $\frac{35}{13}$, (?) $\frac{39}{33}$, $\frac{39}{68}$ (?).]

Divarication of the lateral toes, 70°; of the inner and middle toe, 20°; of the middle and outer toe, 50°. Toes curved inward. Versed sine of the curvature of the middle toe, 0.12 inch. Angle between the axis of the foot and the median line, 30°: that is, the axis of the foot is turned inward that amount. Length of the inner toe, 1 inch; of the middle toe, 1.5 inch; of the outer toe, 1.25 inch; between the tips of the lateral toes, 1.4 inch. Projection of the middle toe beyond the others, 0.6 inch. Distance of the heel from the median line, 0.2 to 0.9 inch. Length of the step 5 to 5.5 inches. Toes narrow, generally sharply accuminate. Width of the trackway, 3 inches.

An outline sketch of this species is given on Plate XIV., fig. 12. I regret that no ambrotype sketch was taken of the row of tracks on No. $\frac{39}{4}$.

Locality.— On the gray shale of Turner's Falls, below the cataract, where it was dug out by Dexter Marsh.

II.—TETRADACTYLOUS.

GENUS III.—ORNITHOPUS. (From ὄρνις, a bird, and πούς, a foot.)

Three toes pointing forward; the hind toe lying nearly on a prolongation backward of the outer toe and on the inside of the foot.

Remark.—These characters would apply almost exactly to the feet of Gallinaceous birds, and hence the name given to the genus—meaning *a bird's foot.* In my opinion, however, it is not always easy to distinguish between the feet of some lizards of oolitic days and those of living birds. But more of this in another place.

Species 1. ORNITHOPUS GALLINACEUS.

Ornithoidichnites tetradactylus of Massachusetts Geological Report, Plate 46, fig. 42.

Ornithopus gallinaceus. Fossil Footmarks of the United States, Plate VIII., fig. 1.

[In the Cabinet, Nos. $\frac{31}{2}$, $\frac{31}{53}$, $\frac{31}{80}$, $\frac{32}{25}$, $\frac{32}{27}$, $\frac{32}{44}$, $\frac{33}{5}$, $\frac{33}{25}$, $\frac{37}{24}$, $\frac{41}{4}$, $\frac{41}{5}$, $\frac{41}{48}$, $\frac{41}{49}$, $\frac{32}{41}$, $\frac{34}{10}$, $\frac{37}{25}$.]

Divarication of the lateral toes, 80°; of the inner and middle toe, 35°; of the middle and outer toe, 45°; of the middle and hind toe, 145°; of the axis of the foot and the median line, 0° to 5°. Length of the inner toe, 1.7 inch; of the middle toe, 3 inches; of the outer toe, 2 inches; of the hind toe, 1.7 inch; of the part of the heel that impressed the mud in walking, about an inch; of the foot, reckoning from the end of the heel, 3.8 inches; of the step, about 7 inches; of the middle toe beyond the others, 1.5 inch. Distance between the tips of the lateral toes, 2.7 inches; between the inner and middle toe, 2 inches; between the middle and outer toe, 2 inches; between the middle and hind toe, 4.4 inches. Width of the toes from 12 to 20 inches. Foot plantigrade, and sometimes calcigrade. Lateral toes curved outward at their tips. Hind toe slightly curved towards the heel; lying on a prolongation backward of the outer toe. Heel or tarsal bone sloping backward so as to impress the mud, 0.5 inch wide. Width of the trackway, 3.5 ? inches.

Track shown of the natural size on Plate XIV., fig. 10. An ambrotype sketch of a single track shown on Plate LVIII., fig. 1.

Localities.—On the Wethersfield red shale, at Chicopee Falls, and the Horse Race, in Gill.

Remarks.—This species bears a strong resemblance in the size and form of its track, as already remarked in general as to the genus, to some of the more common domestic gallinaceous birds. The leg bone, however, in the fossil animal, seems not to have been erect like that in most birds, but to have sloped backward from the foot, so as not to have formed a very large angle with the ground; and herein do we see an approach to the structure of some reptiles, and a little farther on we shall see how small a change would be necessary in the track, to convert it into a lizard's. If the fourth toe were to take its rise a little farther back on the tarsus, and go off from it nearly at right angles, we should have a lizard's foot. Or if the fourth toe were to be obliterated, or fail to make an impression, we should get a track hardly distinguishable from a Platypterna.

Nor am I disposed to deny that such changes are impossible among the phenomena of tracks. But until we can find these changes on well marked specimens, we have no right to presume upon their occurrence.

Species 2. Ornithopus gracilior.

Ornithoidichnites gracilior of Massachusetts Geological Report, Plate 46, fig. 43.
Ornithopus gracilior of Fossil Footmarks of the United States, Plate VIII., fig. 2.

[In the Cabinet, Nos. $\frac{27}{6}$, $\frac{27}{19}$, $\frac{31}{37}$, $\frac{31}{74}$, $\frac{31}{75}$, $\frac{41}{14}$, $\frac{32}{8}$ (bis), $\frac{41}{47}$.]

Divarication of the lateral toes, 90°; of the inner and middle toe, 35°; of the middle and outer toe, 57°; of the middle and hind toe, 105°. Length of the middle toe, 1.1 inch; of the outer toe, 1.2 inch. Hind toe articulated high upon the tarsus, so that only 0.4 inch impresses the ground; its whole length being at least 0.9 inch. Middle toe keel-shaped. Toes nearly straight. Length of the foot, exclusive of the hind toe, 1.6 inch; of the step, 6 inches; of the middle toe beyond the rest, 0.75 inch. Distance between the tips of the lateral toes, 1.8 inch; between the inner and middle toe, 1 inch; between the middle and outer toe, 1.2 inch; between the middle and hind toe, 2 inches. Width of the toes, 0.12 to 2 inches. Width of the trackway, 4.5 inches. Track shown of the natural size on Plate XIV., fig. 11. An ambrotype sketch of a single track is also shown on Plate LVIII., fig. 7.

Locality.—Red shale of Wethersfield.

Remark.—Here again we have a remarkable resemblance in the track of this species to that of the common domestic hen, especially in the hind toe, which in that bird often shows only its extremity upon the mud or snow. But I have only a few good specimens, and, therefore, would be cautious in drawing conclusions from them. Would that I could have explored more thoroughly that remarkable locality of footmarks at the Cove in Wethersfield!

Genus IV.—TRIDENTIPES. (From *tridens*, a trident, and *pes*, a foot.)

Ornithichnites. American Journal of Science, Vol. XXIX., p. 319.
Ornithoidichnites. Massachusetts Geological Report, Plate 40, fig. 27.
Steropezoum. Fossil Footmarks of United States, Plate V., fig. 1.

Three toes directed forward, more or less keel-shaped. Fourth toe inside, nearly on a prolongation backward of the outer toe. Heel stout: the leg sloping upward back of the toes at a very small angle; leaving ridges and furrows often upon the mud towards its posterior part, as if made by stiff hairs or feathers.

Remarks.—This genus I have until recently described as having but three toes, under the name of Steropezoum. But a fourth toe has been found in all the species, mainly by a careful cleaving of the specimens. It differs from the Ornithopus chiefly by the more striking development of its heel in the track. This fact shows that the long tarsal bone, (or if a bird, the tarso-metatarsal,) lay almost flat upon the ground when the animal walked, as is the case with some lizards, batrachians, and a few birds. I have been in much

doubt, however, whether I ought to separate this genus from the Ornithopus. I do it on the ground that not unlikely the former may prove to have been lizards. I give up the name Steropezoum, because, although it be very appropriate to call the first species *an animal giant*, the third is too small for such a designation. But *trident-footed* is appropriate for them all.

Species 1. TRIDENTIPES INGENS.

Ornithichnites ingens. American Journal of Science, Vol. XXIX, p. 319.
Ornithoidichnites ingens. Massachusetts Geological Report, Plate 40, fig. 27.
Steropezoum ingens. Fossil Footmarks of the United States, Plate V., fig. 1.

[In the Cabinet, Nos. $\frac{16}{12}$, $\frac{17}{5}$, $\frac{17}{6}$, $\frac{19}{13}$, $\frac{34}{1}$, $\frac{37}{1}$.]

Divarication of the lateral front toes, 107°; of the inner front and middle toe, 50°; of the middle and outer toe, 58°; of the hind and middle toe, 130°. Length of the hind toe, 5 inches; of the inner front toe, 8 inches; of the middle toe, 9.5 inches; of the outer toe, 5.7 inches; of the heel where it reaches the ground, 9 inches; width of do., 3 inches; length of the foot, 18 to 25 (?) inches; of the step, 40 to 72 inches; of the middle toe beyond the lateral ones, 5.5 inches. Distance between the tips of the lateral toes, 11.3 inches; between the inner front and middle toe, 7 inches; between the middle and outer toe, 7.3 inches; between the hind and middle toe, 16.5 inches; versed sine of inward curvature in the middle toe, 0.3 to 0.7 inch; do. of the outer toe inward, 0.3 to 0.5 inch. Width of the toes, from 0.4 to 1.1 inch. Foot plantigrade; toes somewhat keel-shaped, so as to leave an arch between the toes and the heel; that is, the heel and the middle of the toes sink deepest into the mud, which is crowded upwards in the space between them, Rugosities or ridges beneath the posterior part of the heel, on the track, somewhat radiating. occasioned probably by the adhesion of the mud to the heel, as the animal lifted its foot. Track shown of the natural size on Plate XV., fig. 1.

Localities.—I first found the tracks of this species at the Horse Race in Gill, but succeeded in obtaining only a single specimen, and that so imperfect that I did not discover a hind toe. From that I gave the figure in Fossil Footmarks of the United States, Plate V., fig. 1. Afterwards I found that Professor C. U. SHEPARD had a better specimen in his Cabinet at Amherst, from which the drawing in this Report was taken, and this shows a hind toe very distinctly; and on a re-examination of my first specimen I can discover the fourth toe there also. Professor SHEPARD's specimen was from Northampton, east base of Mount Tom. I am now inclined, also, since the discovery of the fourth toe, to refer *Ornithopus Adamsanus* of Fossil Footmarks to this same species; although the former is considerably smaller. This was found in Montague City, about a mile south of Turner's Falls, a little east of the old Canal, on the former Boston road. So that we have now three localities of this remarkable species, the most gigantic of all the narrow-toed species, and able, apparently, to compete with Brontozoum giganteum itself.

Species 2. TRIDENTIPES ELEGANS.

Steropezoum elegans. Fossil Footmarks of the United States, Plate V., fig. 2.
Ornithichnites diversus. American Journal of Science, Vol. XXIX., fig. 22.
Ornithoidihcnites elegans. Massachusetts Geological Report, Plate 41, fig. 28.

[In the Cabinet, Nos. $\frac{16}{5}$, $\frac{16}{7}$, $\frac{18}{1}$, $\frac{18}{2}$, $\frac{21}{6}$, $\frac{21}{8}$, $\frac{26}{21}$, $\frac{33}{2}$, $\frac{33}{12}$, $\frac{33}{29}$, $\frac{15}{15}$, $\frac{20}{7}$, $\frac{22}{14}$, $\frac{26}{21}$, $\frac{32}{4}$, $\frac{40}{62}$.]

Divarication of the lateral toes, 125°; of the inner front and middle toe, 65°; of the middle and outer toe, 60°; of the middle and hind toe, 140°. Length of the hind toe, 1.8 inch; of the inner front toe, 1.8 inch; of the middle toe, 2.8 inches; of the outer toe, 2.2 inches; of the heel where it reaches the ground, 2.4 inches; width of the same, 0.5 inch; length of the foot, 5 inches; of the step, 10 to 20 inches; of the middle toe, beyond the others, 2 inches. Width of the toes from 0.26 to 0.42 inch. Distance between the tips of the lateral toes, 3.5 inches; between the inner front and middle toe, 2.5 inches; between the middle and outer toe, 2.6 inches; between the hind and middle toe, 5.3 inches; versed sine of the curvature inward of the middle toe, 0.2 inch. Inner and outer front toes slightly curved. Angle of the axis of the foot with the median line, 0° to 10°. Distance of the middle of the heel from the median line, 0.5 to 3.5 inches. Width of the trackway, 7 inches.

An outline of this track of the natural size is shown on Plate XV., fig. 2. It is also shown on the ambrotype sketches on Plate XLV., fig. 6, and on Plate LII., figs. 8, 9, 10 and 11.

Localities.—This was the animal that made the track from Marsh's quarry in the south-west part of Montague, which first arrested the attention of DEXTER MARSH, as he was laying it down in the side-walk in Greenfield, and which was subsequently purchased at my request by Dr. DEANE for my cabinet. The specimen consisted of a slab 34 inches by 36, which was split open; and that side which had the depressed tracks upon it I supposed to be the surface on which the animal trod. There the track was tridigitate; nor did I discover the fourth toe till recently, when suspending the specimens in a frame, I cleaved off some of the surface, and found that the tracks which I had described were an inch at least below where the animal trod. The specimen now forms what I call the *Great Folio*, of four pages, all of which are shown on Plate LII.; the two first pages on figs. 11 and 10, and the two second on figs. 9 and 8. The volume finely illustrates the subject of tracks.

Another locality is on the banks of Connecticut River in the north part of Montague; another, two miles south of Turner's Falls; another at the Horse Race in Gill.

Species 3. TRIDENTIPES ELEGANTIOR. (NOV. SP.)

[In the Cabinet, Nos. $\frac{19}{9}$, $\frac{20}{7}$, $\frac{20}{9}$, $\frac{20}{10}$, $\frac{33}{7}$, $\frac{36}{39}$.]

Divarication of the lateral toes, 75°; of the inner and middle toe, 32°; of the middle and outer toe, 44°; of the middle and hind toe, 140°; of the axis of the foot with the line of direction, 0° to 10°. Length of the inner toe, 0.6 inch; of the middle

toe, 1 inch; of the outer toe, 0.9 inch; of the hind toe, 0.4 inch; of the heel, 0.7 inch; of the foot, 1.8 inch; of the step, 5.3 inches; width of the toes from 0.14 to 0.25 inch. Distance between the tips of the lateral toes, 1.1 inch; of the inner and middle toes, 0.8 inch; of the middle and outer toe, 0.9 inch. Projection of the middle toe beyond the others, 0.6 inch. Width of the trackway, 1.75 inch.

An outline of this track of natural size is given on Plate XV., fig. 3. Plate XLV., fig. 1, also shows a case quite unusual among fossil footmarks where the animal turned completely about on a very short curve. This fact forms the foundation of a moral conclusion of much interest which I shall notice in the conclusion.

Remarks.—This species is not, as may be supposed, identical with the Steropezoum elegantior of the Fossil Footmarks of the United States. I have not been able to discover a fourth toe upon this latter, and as it differs but little, except in size, from Tridentipes elegans, I drop it out as a species; although by so doing I leave some specimens in the Cabinet which I cannot name.

Species 4. Tridentipes insignis.

Ornithoidichnites divaricatus of Massachusetts Report, Plate 44, fig. 36.

Ornithopus loripes of Fossil Footmarks of United States, Plate VIII., fig. 3.

[In the Cabinet, Nos. $\frac{1}{4}$, $\frac{5}{10}$, $\frac{5}{11}$.]

Divarication of the lateral toe, 95°; of the inner and middle toe, 45°; of the middle and outer toe, 50°; of the hind and middle toe, 100°. Length of the inner front toe, 4.3 inches; of the middle toe, 5.3 inches; of the outer toe, 4.3 inches; of the inner toe, 3.2 inches; of the foot, 6 to 7 inches; of the part of the heel making an impression in walking, 1 to 2 inches; width of the same, 1.5 inch; length of the step, 16 to 23 inches; of the middle toe beyond the rest, 2.5 inches; width of the toes from 0.5 to 0.7 inch. Distance between the tips of the lateral front toes, 6.3 inches; between the middle and inner front toe, 4 inches; between the middle and outer toe, 4 inches; between the middle and hind toe, 6.8 inches. Versed sine of curvature of the hind toe, 0.2 inch; of the inner front toe, 0.4 inch; of the middle toe, 0.6 inch; of the outer toe, 0.2 inch. Angle between the axis of the foot and the median line, 10°, inwards. Distance of the middle of the heel from the line of direction, 3 inches. Width of the trackway, 12.5 inches. Outline of the track of natural size shown on Plate XV., fig. 4. Rows of this track are also shown on Plate XLV., fig. 3, and Plate XLVII., fig. 2.

Localities.—South-west part of Montague; Horse Race, Gill; Northampton; Chicopee; Wethersfield, Connecticut.

Species 5. Tridentipes uncus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{6}{1}$, $\frac{9}{10}$, $\frac{14}{6}$, $\frac{11}{2}$, $\frac{11}{4}$, $\frac{17}{8}$, $\frac{31}{4}$, $\frac{32}{3}$, $\frac{35}{17}$, $\frac{36}{7}$, $\frac{19}{8}$, $\frac{21}{5}$, $\frac{32}{1}$.]

Divarication of the lateral front toes, 90°; of the inner front and the middle toe, 48°; of the middle and outer toes, 44°; of the middle and hind toe, 70°. Length of the middle toe, 2.2 inches; of the inner front toe, 1.7 inch; of the outer do., 1.4 inch; of the hind toe,

1.1 inch; of the heel, 1.1 inch; width of do., 0.9 inch. Length of the foot, 3.2 inches; of the step, 4.5 to 5 inches; of the middle toe beyond the rest, 1 inch. Distance between the tips of the lateral front toes, 2.2 inches; between the middle and inner toe, 1.4 inch; between the middle and outer toe, 1.6 inch; between the middle and hind toe, 2.3 inches. Versed sine of curvature in the hind toe, 0.1 inch; in the inner front toe, 0.15 inch; of the middle toe, 0.2 inch; of the outer toe, 0.1 inch. Angle between the axis of the foot and the median line, the foot turned inward, 5° to 20°. Distance between the middle of the heel and the median line, 1.5 inch. Width of the trackway, 10 inches.

Outline of the track shown of the natural size on Plate XV., fig. 5. A row of these tracks is shown also on Plate XLVI., fig. 1.

Locality. — Turner's Falls, Lily Pond Quarry.

Affinities of the Group.

Living biped animals with tridactylous or tetradactylous feet are birds, with only one or two unimportant exceptions in the Batrachian class. The same characters in the preceding group afford a presumption that the animals which made these tracks were also birds. The position of the hind toe, likewise, in the second sub-group, corresponds to that of many four-toed birds; especially where, as in Ornithopus gracilior, the hind toe is inserted so high on the tarsus that its extremity only reached the ground, giving the track precisely the appearance of that of the common dunghill fowl.

Another fact corroborative of the conclusion that at least some of the animals of this group were birds, has been ingeniously applied by Dr. SAMUEL L. DANA, of Lowell. He has carefully analyzed the coprolites found in connection with the tracks of Argozoum Redfieldianum, and detected in them about one-half of one per cent. of uric acid. The whole analysis stands as follows. (See American Journal of Science, Vol. 48, p. 46.)

Water, organic matter, urate, and volatile salts of ammonia,	10.30
Chloride of Sodium,	.51
Sulphates of Lime and Magnesia,	1.75
Phosphate of Lime and Magnesia,	39.60
Carbonate of Lime,	34.77
Silicates,	13.07
	100.

By subsequent analysis Dr. DANA ascertained that the amount of uric acid was about one-half of one per cent.; and after going into an extended comparison and course of reasoning, showing that this could not be the coprolite of reptiles or carnivorous birds, he says, "the conclusion seems inevitable, that it has been dropped by a bird belonging to the class which has deposited the beds of guano," that is, by omnivorous birds.

On the other hand, however, some circumstances create a doubt whether the tracks of this group are those of birds at all. One is, as I shall attempt to show, that we find among the tracks to be described, some that are undoubtedly quadrupedal and yet are tridactyle; their quadrupedal character being determined chiefly by the position of the feet as the

animal walked; namely, two tracks (of unequal size, however) coming close together with a wide interval to the next two. Viewed apart, each of these tracks would be, mistaken for some of the tridactyle impressions described under the last group; and the inquiry cannot but arise, whether one of the feet of these animals may not have failed to make an impression, or its track may not yet be discovered.

Another suspicion of the like kind may be awakened by the lizard-like aspect as to the feet, of some of the four-toed tracks above described; especially those of the Tridentipes. I refer particularly to the curvature of their toes, which is certainly more common in lizards and chelonians than in birds.

Such suggestions, however, can hardly outweigh the positive arguments in favor of the ornithic type of most of this group. Even if some of them should turn out to be quadrupeds, as is not improbable, we ought not to allow such a possibility to transfer the whole sixteen from bipeds to quadrupeds; or even any of them, without further proof.

GROUP IV. — ORNITHOID LIZARDS OR BATRACHIANS.

Remarks.—I have found it an extremely difficult matter to distinguish by their tracks between the Batrachian Tritons and Salamanders on the one hand, and some Lizards on the other. These families were formerly united and are now distinguished chiefly by the smooth skin of the former and the scaly skin of the latter. Most of the lizards have, indeed, five toes, both behind and before,—excepting the crocodile tribe; whereas the Salamanders have only four toes in front. But in small tracks, so minute are some of the toes that they are often overlooked or not present in the track, and, therefore, I dare not take this character as a criterion. In these circumstances I have brought together certain species under a name which embraces both these tribes, and yet they have marked ornithoid characters. Some of this Group appear to me to have been perhaps more peculiar in their characters than any others whose tracks are in our cabinets; and some of them have been, till this time, unhesitatingly referred to birds; and indeed the ornithic type is strongly marked; but other characters bring them into the lizard or batrachian family. But I will give details.

Genus I.—GIGANTITHERIUM, (*γιγας*, a giant, and *θηϱιον*, a wild beast.)

Three thick toes pointing forward; a fourth, short and rather narrow, coming out near the posterior end of the inner toe, and curved outward. Toes with claws. Tracks arranged nearly on a right line, ornithoid. Tail dragging behind, and passing through the middle of the tracks. Animal bipedal.

Species 1. Gigantitherium caudatum.

Gigandipus caudatus, American Journal of Science, Vol. 21, New Series, p. 96.

[In the Cabinet, Nos. $\frac{9}{9}$, $\frac{9}{10}$, $\frac{30}{2}$.]

Divarication of the lateral toes, 53°; of the inner and middle toe, 22°; of the middle and outer toe, 30°; of the middle and hind toe, 120°. Length of the foot from the tip of

the middle toe to the end of the heel, or inner toe, 17.5 inches; of the inner toe, 13.5 inches; of the outer toe, 13 inches; of the hind toe, 3.3 inches; of the step, 3.9 inches. Thickness of the inner toe, 3 inches; of the middle toe, 3 inches; of the outer toe, 3.5 inches; of the hind toe, 0.7 inch. Claws at least an inch long, probably more; accuminate. Inner toe extending backward farther than the outer one. Distance from tip to tip of the front lateral toes, 11.5 inches; between the inner and middle toe, 6.6 inches; between the middle and outer toe, 7.5 inches; between the middle and hind toe, 17.25 inches. Middle toe prolonged beyond the others, 4.3 inches. Axis of the foot coincident with the line of direction. Tracks rarely out of a right line. Right and left foot in the tracks distinguishable by the position of the inner or hind toe, which points inward alternately from the right and left side of the tracks. Versed sine of the curvature of the hind toe, 0.4 inch. The trace of a long tail in the line of the tracks is very manifest, passing across the middle of the tracks, except where the animal changed its course. Width of the trace, from a quarter to half an inch, with a somewhat feathery appearance on each side, such as is exhibited by the slight ripple in water, when a stick is drawn rapidly through it. Tracks ornithoid; tail reptilian. Width of the trackway, 12 inches.

Outline of the foot shown of the natural size, on Plate XVI., fig. 1. Fig. 2 shows the tail swinging to the right and the left. An ambrotype sketch of the best slab in the Cabinet is shown on Plate XLIV., fig. 4. The three first tracks on this figure are in a right line; at the fourth step, the animal veered a little to the right, which caused the tail to curve in the same direction.

It has been suggested that this trace upon the stone was made by the animal's toe, rather than by a tail. But in that case it would not be so continuous, and could be traced to the toe that made it, as other examples to be described prove. Nor in that case would it it ever leave any impression on the track, as is sometimes faintly seen in the Gigantitherium.

Plate XVI., fig. 2, is a sketch by Roswell Field, not intended to be perfectly accurate, of a row of tracks of this animal, with a tail-trace sweeping to the right and left. The specimen was unfortunately destroyed; but I saw a part of it with the tail-trace that corresponded to this figure. Such a serpentine trackway I suppose to be the result of an animal's taking unusually long strides, and it is conclusive proof that the trace was made by a tail instead of a foot.

When I first found the tracks of this animal I called it Gigandipus, or the Giant-footed biped, because I had no evidence that it had more than two feet. Nor have any more been discovered; but in so many instances I have found that a supposed biped turned out to be a quadruped, that I judged it best to change the name, and call it Gigantitherium; which means a giant animal merely; so that if it turns out to be a quadruped, the name may still be good and not teach an error, as Gigandipus would.

The nearly rectilinear succession of the tracks of this animal is a remarkable fact whether it be biped or quadruped. For it affords strong evidence that it had long legs No living animal of this size, if indeed there are any living ones with feet so large,—moves so nearly in a right line, unless it be the large grallæ, or wading birds. And when I first glanced at the tracks, I thought only of a bird's foot. But when I saw the tail-track, my

imagination was filled at once with a gigantic biped lizard, or batrachian. But if such was its nature, how high must it have been stilted up! How unlike existing nature! And whatever we imagine its nature to have been, we cannot but be satisfied that its type differed much from that of living animals.

Locality.—The tracks of this as well as of the next species, was discovered by ROSWELL FIELD at the Lily Pond on his farm. The specimen figured on Plate XLIV., fig. 4, is undoubtedly the best yet found. But others were obtained; two of which are in the Ichnological Cabinet; (see Plate XLIV., fig. 6, for one of them,) and two others were sent to Dr. JOHN C. WARREN, and are now deposited by his sons in the fire-proof Mastodon Cabinet erected by their father in Boston, along with many other fine specimens of foot-marks and splendid fossils, the whole forming one of the most magnificent private cabinets in the country, or in the world.

Mr. FIELD, who disinterred all the specimens of the tracks of Gigantitherium yet found, is confident that no marks of the fore feet existed; and from his great skill and caution in such manipulations, I cannot believe they would have escaped his notice. At present, therefore, we must go on the supposition that the animal was a biped. Yet it would not be strange if the fore feet should be hereafter brought to light.

Species 2. GIGANTITHERIUM MINUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{3}$, $\frac{20}{2}$, $\frac{20}{6}$, $\frac{21}{1}$, $\frac{30}{2}$, $\frac{34}{41}$.]

Tridactylous; divarication of the lateral toes, 43°; of the inner and middle toe, 30°; of the middle and outer toe, 12°. Length of the inner toe, including probably a tarsal bone 1.3 inch long, which impresses the mud, 5.8 inches; of the middle toe, 5.4 inches; of the outer toe, 5.1 inches; of the foot, 8 inches; of the step 26 to 34 inches. Width of the inner toe, 0.9 inch; of the middle toe, 1.3 inch; of the outer toe, 1.3 inch. Length of the first phalanx of the middle toe, 1.3 inch; of the second, 1.25 inch; of the third, 1.9 inch; of the claw and perhaps ungual phalanx, 0.8 inch; of the first phalanx of the outer toe, 1.4 inch; of the second, 1.5 inch; of the third, 1.3 inch; of the claw and ungual phalanx, 1 inch; of the phalanges of the inner toe, unknown; of the tarsal bone (?) which impresses the ground, 1.3 inch, and is narrower than the toe; nor does it make so deep an impression; for both which reasons it is judged to be a tarsal bone. Distance between the tips of the lateral toes, 5.8 inches; between the inner and middle toe, 4.7 inches; between the middle and outer toe, 3.3 inches. Projection of the middle toe beyond the others, 2.7 inches. Width of the trackway, 6.5 inches.

Tail making a distinct trackway along the animal's course, 0.15 inch wide.

Outline of the track of natural size shown on Plate XVII., fig. 1. Several tracks of this species, with the marks of the tail, are shown on Plates XLI., fig. 2, and XLII., fig. 2, as taken by an ambrotype sketch.

Locality.—Lily Pond, on Mr. FIELD's farm, with the G. caudatum.

Remarks.—I bring this track into the genus Gigantitherium, although I have as yet found but three toes; for it obviously belongs to the same type, which is more easily

recognized by the eye than by description. Perhaps the extension backward of the inner toe beyond the outer one, and the consequent greater length of the inner one, is the most striking peculiarity; for I have never before met with a tridactylous pachydactylous track, whose inner is longer than the outer toe. As this species, however, has no hind toe, I could not determine which is the inner toe, did I not take the G. caudatum as a guide; for the fourth toe in that species comes out from the longest toe, and I cannot believe, contrary to all analogy living and fossil, I think, that a fourth toe like this proceeds from the outward toe. And, moreover, noticing especially in the G. minus that an impression appears on the longest toe about equal in length to a phalanx at its posterior extremity, and makes not so deep or wide an impression as the main body of the toe, though it curves a little outward beyond the exterior line of the toe, I infer that here some of the tarsal bones reached the ground, and should not be reckoned in estimating the length of the toe. Making this deduction as accurately as I have been able to determine the point, and it leaves the inner toe about as much shorter than the outer one as is usual in the thick-toed tracks that have been described. I, therefore, regard what seems to be the longest toe in G. minus as the inner one, as we know it to be in G. caudatum.

Nor do I regard the absence of a fourth toe in the G. minus a sufficient reason for excluding it from this genus. For much experience has shown that this toe so often failed to make an impression in walking, that many well-marked tracks often appear without it. The next species to be described presents us with several long rows of deep and distinct tracks, and yet on only one or two broken fragments is a hind toe visible.

But though the hind toe be wanting in the G. minus, the claws and some of the phalanges are much better developed than in G. caudatum. But their occurrence in the former makes their existence in the latter highly probable. I regret that as yet I am unable to make out the number of the phalanges in the inner toe. If they are three, as they appear to be in the other toes, the question would press strongly upon us, whether these remarkable animals were not mammiferous; since the phalanges in all their toes are three. And such a suggestion would be strengthened by the length of their legs; for the G. minus appears to have moved nearly in a line, as well as the other species; and this could not be without long legs.

The question may be raised whether the G. minus is not a young G. caudatum. This is quite possible, as the general form of the tracks is the same. But the G. minus appears to me to be more slender and delicate, and could hardly become the G. caudatum by growth. Then, if identical, I cannot see why a fourth toe is not found in the former, while it occurs in nearly every track of the latter, which I have seen. Moreover, if identical, we ought to find tracks of various intermediate sizes, which as yet has not been done; so that with our present knowledge, I feel justified in making two distinct species of this genus.

GENUS II.—HYPHEPUS. (Υφή, a web, and πούς, a foot; the web-footed animal.)

Tetradactylous; three toes pointing forward. Space between the toes filled up and scalloped in front between the tips, as if a membrane had impressed the mud in the form of a web. Caudate, bipedal, track ornithoid.

Species 1. HYPHEPUS FIELDI. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{3}$, $\frac{20}{6}$, $\frac{29}{1}$, $\frac{30}{2}$, $\frac{40}{60}$ (bis), $\frac{40}{61}$, $\frac{20}{1}$, $\frac{16}{1}$.]

Three toes pointing forward; divarication of the lateral front toes, 50°; of the inner and middle toe, 23°; of the middle and outer toe, 28°; of the middle and hind toe, 152°. Lateral toes rounded and rarely showing a claw, as if the web reached their extremities; middle toe attenuated near its extremity, but rarely showing a claw. Tail generally passing so directly through the tracks as to destroy the marks of a claw on the middle toe. Length of the inner toe, 3 inches; of the middle toe and the foot, 5 inches; of the outer toe, 2.9 inches; of the hind toe, 1 inch; of the step, 6 inches. Between the tips of the lateral toes, 2.8 inches; between the inner and middle toe, 2.3 inches; between the middle and outer toe, 2.5 inches; between the middle and hind toe, 5.2 inches. Middle toe projecting beyond the rest, 2 inches; hind toe curved very much backward. Versed sine of curvature, 0.25 inch. Width of tail furrow, 0.15 inch. No phalanges visible. Web extending apparently over the whole foot. Axis of the foot turned inwards towards the median line, about 5°; heel distant from that line, 1 to 1.5 inch. Width of the trackway, 5.3 inches.

Outline of the track and tail furrow of the natural size, shown on Plate XVII., fig. 2. A long row of these tracks is also given on Plate XXXV., fig. 11, separated from the other tracks on the same slab. This row was taken from the slab sketched on Plate XLI., fig. 2. A track is also exhibited on Plate XLII., fig. 2; from all of which I hope a good idea of it may be obtained.

Locality.—Lily Pond, Gill.

Remarks.—The tracks of this species occur on the same surface as those of the Gigantitherium, and their general form, with the crooked hind toe, closely resembles those of this genus. It is chiefly because the evidence of a web is so marked, while it is entirely wanting in the Gigantitherium, that I have placed this species under Hyphepus. Yet I am not without some apprehension, from what I have seen in some other tracks, that no web existed. But upon the whole, I leave it under this genus. As Mr. FIELD not only discovered the track, but pointed out the web, I have attached his name to it as the discoverer. If the web should be proved not to exist, then it will fall in as a third species of Gigantitherium, with the same specific name. In all the specimens in the Cabinet, which are numerous, and fine, I have seen no mark of a forward foot. Here then we have three species, which, with our present knowledge, must be regarded as bipedal lizards, or batrachians. The tail effectually cuts off the idea of their having been birds; and yet the shape of the foot is strongly ornithoid; and so is the mode of progression. I must believe

that these animals combined characters now found distributed among birds, lizards, batrachians, and perhaps mammalia.

GENUS III.—CORVIPES. (*Corvus*, a crow, and *pes*, a foot, from the resemblance of the tracks to that of a crow.)

Quadrupedal; hind foot tridactylous, (tetradactylous?) unguiculate, ornithoid. Fore feet pentedactylous, toes curved, lacertiloid. Toes on both feet curved towards the median line.

Species 1. CORVIPES LACERTOIDEUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{16}{5}$, $\frac{22}{1}$, $\frac{32}{1}$, $\frac{33}{18}$, $\frac{34}{21}$, $\frac{34}{22}$, $\frac{34}{28}$, $\frac{34}{37}$, $\frac{34}{39}$, $\frac{37}{24}$, $\frac{41}{10}$, $\frac{33}{25}$, $\frac{33}{27}$, $\frac{34}{19}$.]

Hind Foot.—Divarication of the lateral front toes, 75°; of the inner and middle toe, 40°; of the middle and outer toes, 35°. Angle (inward) between the axis of the foot and the median line, 0 to 10°. Versed sine of the inward curvature of the middle toe, 0.2 inch. Length of the inner toe, 1.7 inch; of the outer toe, the same; of the middle toe, 1.7 inch; of the claw, 0.2 inch; of the heel, 0.9 inch; of the foot, 2.6 inches; of the step, 1.7 to 2.7 inches. Distance of the middle of the heel from the line of direction, 0 to 1.5 inch. Perhaps a very short hind toe coming out of the heel just back of the roots of the toes; but I have only one indistinct specimen that leads me to suspect it, and what I call the heel, may be a hind toe, as in the crow, for instance. Width of the trackway, 4.6 inches.

Fore Feet.—Pentedactylous; the inner and outer toe nearly on a right line, the inner one pointing backward and straight, the rest curved outward. Length of the outer toe, from the central part of the foot, 0.6 inch; of the second, 0.8 inch; of the third, 0.75 inch; of the fourth, 0.4 inch; of the fifth, 0.4 inch; of the heel, 0.6 inch; of the foot, 1.3 inch. Axis of the foot parallel to that of the hind foot. Position of the fore foot in walking a little in advance of the hind foot, sometimes outside of it and sometimes interfering with it; that is, the animal brought up its hind foot nearly into the place vacated by the fore foot. Track lacertiloid; hence the specific name.

Outline of these tracks shown of the natural size, on Plate XVII., fig. 3. A row of this species is also shown on Plate XLVII., fig. 1, and another on Plate XXXV., fig. 7.

Localities.—This track has been found only in the vicinity of Turner's Falls, at Lily Pond; also lying just above the trap below Turner's Falls, where the rock has been a good deal hardened by contact with the trap. This locality was discovered by Mr. FIELD.

From the same spot I have specimens of the hind feet of an animal of the same genus, considerably larger than that just described, and which I presume to be another species. But as my specimens are few I pass it unnamed.

GENUS IV.—TARSODACTYLUS. (ταρσός, the tarsus, and δάκτυλος, a toe, meaning a foot with a toe coming out on the tarsus above the heel.)

Quadrupedal; hind and fore feet tetradactylous; animal caudate, ornithoid and batrachoid.

Species 1. Tarsodactylus caudatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{6}{1}$, $\frac{33}{35}$.]

Hind Foot.—Tetradactylous, three of the toes pointing forward; pachydactylous; hind toe reaching the ground only with its extremity, on the inner side of the heel, or near the roots of the front toes. Hence it must be inserted high up on the tarsus, as the generic name implies. Divarication of the front lateral toes, 42°; of the inner and middle toe, 20°; of the middle and outer toe, 22°; of the axis of the foot with the line of direction, the foot turned inward sometimes as much as 20°. Distance between the rows of right and left tracks, 4.5 inches. Length of the inner front toe, 1.8 inch; of the middle do. and the foot, 2.9 inches; of the outer toe, 2.2 inches; of the claw, 0.25 inch. From tip to tip of the lateral toes, 1.6 inch; between the inner and middle toe, 1.4 inch; between the middle and outer toe, the same. Projection of the middle toe beyond the rest, 1.1 inch. Length of the step by alternate hind feet, 5.5 to 7 inches; by the right or left feet, 13 inches. All the toes sometimes making a trail, especially the middle one. Track ornithoid. Width of the trackway, 7 inches.

Fore Foot.—Pentedactylous, pachydactylous; turned outward; generally situated outside of the hind foot in walking; often in the same place. Axis of the foot turned outward several degrees. Divarication of the lateral toes, 95°; of the inner and middle, 23°; of the second and third, 20°; of the third and fourth, 25°; of the fourth and fifth, 25°. Length of the outer toe from the middle of the posterior part of the foot, 0.5 inch; of the second, 1.2 inch; of the third, 1.5 inch; of the fourth, 1.65 inch; of the inner or fifth, 0.25 inch. Greatest breadth of the foot, 1.8 inch. Width of the toes, 0.4 inch. Foot lacertiloid or batrachoid.

Trace of the tail nearly straight; scarcely over one-tenth of an inch wide. Outline tracks shown of the natural size, on Plate XVII., fig. 4. Rows of the same, from a slab in possession of Mr. R. Field, shown also on Plate XXXVI., fig. 2.

Locality.—Turner's Falls; I believe Lily Pond is the only known locality.

Remarks.—The hind foot of this species, if we leave out the hind toe, has quite an ornithoid aspect; but the fore foot with its five toes, brings before us a lizard or batrachian; and the tail confirms this supposition. The distance between the rows of tracks, also, looks lizard-like, or even chelonian. I think that while it has some ornithic affinities, it more clearly comes into the reptile class than any other species of this group.

Some have thought that the inward curvature of ornithoid tracks is a pretty sure indication that the animal is a bird. But this case disproves such an opinion.

Genus V.—APATICHNUS, (ἀπατέω, to deceive, and ἴχνος, a track. The deceptive track.)

Quadrupedal; unequal-footed; hind foot tetradactylous; the three principal toes, which are pachydactylous and clawed, directed forward; strongly ornithoid; heel long; tail track serpentine. Fore foot, tetradactylous (pentedactylous?); three first ones curved outward; heel with toe pointing backward.

Species 1. Apatichnus circumagens. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{3}$, $\frac{5}{8}$, $\frac{9}{11}$, $\frac{11}{2}$, $\frac{12}{3}$, $\frac{12}{4}$, $\frac{14}{5}$, $\frac{20}{6}$, $\frac{21}{2}$, $\frac{23}{8}$, $\frac{29}{1}$, $\frac{33}{50}$, $\frac{16}{1}$, $\frac{16}{10}$, $\frac{33}{49}$.]

Hind Foot.—Toes, four; the three front ones stout and thick, very ornithoid; divarication of the outer ones, 75°; of the inner and middle toe, 35°; of the middle and outer toe, 40°; of the middle and hind toe, 110°. Length of the outer front toe, 2.1 inches; of the middle, 2.6 inches; of the inner front toe, 1.7 inch; of the hind toe, 1 inch; but this impressed the mud only over a space of half an inch at the extremity; of the heel, about 2.5 inches; of the foot, 5 inches. Length of the claw on the middle toe, 0.3 inch; phalanges indistinct on the track. Distance between the tips of the lateral toes, 2.3 inches; between those of the inner and middle toe, 1.4 inch; between the middle and outer toe, 1.7 inch; between the middle and hind toe, 3.1 inches; middle toe extending beyond the rest, 1.1 inch. Toes turned toward the line of direction, at an angle of 10°. Distance of the middle of the heel from the median line, half an inch. Length of the step, right and left foot, 4.3 to 7 inches; right foot or left foot, 13 inches. Width of the trackway, 4.5 inches.

Tail rather stout, and swinging to the right and left as the animal advanced, so as to leave a serpentine furrow, which is a quarter of an inch wide, and deviates about 2 inches to the right and left of a straight line.

Fore Foot.—Tetradactylous (pentedactylous?); a heel as long as the toes, running backward with a toe at the end, pointing rather backward, while the three other toes point forward and curve towards the axis of the track; a fifth short toe obscurely visible on the track, on the outside and below the others. Length of the middle toe, 1 inch; of the heel from the same point, half an inch.

Track shown of the natural size, with the heel shown by dotted lines, as far as I have been able to mark it out, on Plate XVII., fig. 5. A sketch of the upper surface of the same slab is also shown on Plate XXXV., fig. 6, whose object is to show the swinging of the tail, occasioned, as I conjecture, by the animals moving with long strides. Plate XXV., fig. 6, shows a fine row of this species with the fore foot. Other slabs of rows of what I suppose to be this track are shown on Plate XLII., figs. 1 and 2, and Plate XLVI., fig. 4.

Locality.—The prolific one at Lily Pond, Turner's Falls; brought to light, with numerous other tracks, by Mr. Field.

Remarks.—The history of this species is remarkable and instructive. For some time I had observed on some slabs in the Cabinet, several fine rows of tridactyle tracks, which I had, almost without thought, referred to birds. I at length observed a much smaller four or five-toed track, occasionally associated with these; just in the place where the front foot of a quadruped would fall (see Plate XXV., fig. 6); and so commonly found there on inspection, that I came to the full conviction that this was a quadruped, with tridactyle ornithoid feet behind. But other discoveries were to come, if I have not identified dissimilar things. On the upper face of a slab, I found the distinct serpentine furrow of an animal's tail, with the indistinct traces of a large and small foot in succession, with a heel quite long. But on splitting off a layer scarcely half an inch thick, I found that the heel and

tail had disappeared; but a quite perfect tridactylous track, and a much smaller one close by it, appeared immediately beneath where the imperfect track showed itself on the original surface. How should this be explained: for the tracks on the two surfaces were evidently made by the same animal, and at the same time. I make the supposition that the mud on which the animal trod was quite soft, which caused him to sink, say half an inch, and then the impression of the feet was more perfect, or rather more permanently perfect, than on the upper surface, and when the feet were withdrawn, the tracks at top were almost obliterated by the collapse of the mud, but the heel and tail, not sinking any lower, left more distinct marks. And I think these facts may give us important hints as to other cases of tracks. It may be, indeed, that I have confounded together different tracks in this case; but they are too much alike to be separated.

If then we look only at the upper surface of this specimen, ($\frac{21}{2}$) we see only evidence of a long heeled and tailed lizard: but the second layer, although a practiced eye would see on it a quadrupedal track, shows the principal one so like that of a bird, that he cannot but believe there was a mingling of the bird with the lizard in the animal's nature.

Species 2. APATICHNUS BELLUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{26}{21}$, $\frac{33}{37}$, $\frac{33}{49}$, $\frac{35}{50}$, $\frac{35}{47}$.]

Hind Foot.—Tetradactylous, ornithoid. Toes stout, three directed forward; divarication of the outer ones, 60°; of the inner and middle, 30°; of the outer and middle, 30°; of the axis of the foot with the median line, 10° to 30°. Distance of the middle of the heel from the median line, 1.5 to 2.5 inches. Length of the hind toe, 0.2 inch; of the first front toe, 0.4 to 0.7 inch; of the middle toe, 0.8 to 1 inch; of the outer toe, 0.6 to 0.8 inch; of the middle beyond the rest, 0.3 inch; between the tips of the lateral toes, 0.7 inch. Length of the step, right to left foot, 3 to 4 inches; from right to right, or left to left, 6.8 inches. Track plantigrade, strongly ornithoid. Width of the trackway, 2.5 inches.

Fore Foot.—Tridactylous; (perhaps tetradactylous,) ornithoid. Divarication of the outer toes, 40°. Length of the foot, about 0.5 inch. Width, the same. Axis of the foot nearly coincident with the line of direction. Position of the foot slightly in advance of the hind foot in walking.

An outline of the tracks of this species is given on Plate XVII., fig. 6. A row of the same is shown on Plate XXXV., fig. 8, taken from a slab in possession of ROSWELL FIELD. An ambrotype sketch is likewise given on Plate XLV., fig. 6 of slab No. $\frac{26}{21}$ in the Cabinet, on which are quite a number of rows of this species, along with one row of Tridentipes elegans.

Locality.—Turner's Falls, on Mr. FIELD's farm.

Remarks.—I have been in doubt whether to refer this species of tracks to Apatichnus, or Plesiornis. But the much greater disparity between the fore and hind feet than is usual in the latter genus, has led me to refer it to the former.

GENUS VI.—PLESIORNIS, (πλησίος, near, and ὄρνις, a bird.)

Tridactylous, pachydactylous, hind foot slightly the largest. Toes slightly turned towards the line of direction; terminated by blunt claws, or pellets. Highly ornithoid; the tracks distinguished from those of birds only by being arranged two by two along the median line, with a wide interval between.

Remarks.—Almost to the present time, all ichnologists have regarded the tracks I am about to describe under this genus, as those of a bird. Some, indeed, suppose they can see the same number of phalangeal impressions from the toes, as in birds—a point about which I do not feel fully settled, since bird tracks closely allied have been confounded with these. My eyes, indeed, were partially opened as to the character of this animal, as long ago as 1842, when I described some of these tracks and figured them in the Transactions of the American Association of Geologists and Naturalists, in which I said of the remarkable slab there figured, but now mostly lost, that "on the right hand side of the drawing two rows of tracks are seen almost exactly on the same line, and situated with respect to each other precisely like those of some quadrupeds." But I explained it, as all have, by "the presumption that the same animal walked twice along the same line, or that one followed another." As most of the fine slab figured in that work was destroyed, (see Plate XI., fig. 4 of that work,) that explanation answered well enough, till I happened to stop one evening in the entrance hall of the Boston Society of Natural History, where the gas light showed the splendid fossil footmarks lining the walls, and there I saw at least two distinct cases of these double rows of tridactyle footmarks; and I became satisfied that so much of system could not be accidental, and that the animal which made those rows must have been a quadruped. I could not discover a fourth toe, and yet I have not been able to study those slabs with the intense care requisite in some cases to detect unusual markings. I, therefore, give these animals as three-toed quadrupeds, both before and behind; but it may not unlikely be discovered that they had at least four toes; and yet their tracks are very deep, and it seems strange that such additional toes are not visible upon the Boston slabs, if the animals had them. But the existence of lizards among living animals with three toes on the fore foot, is not an unheard of thing, as Plate VI., fig. 9, showing a living lizard, will prove. And then the Proteus, a Batrachian, has only three toes before and two behind.

Species 1. PLESIORNIS QUADRUPES. (Nov. Sp.)

Ornithoidichnites fulicoides. Transactions of Association of Geologists and Naturalists, Plate XI., fig. 9, p. 258.

Æthiopus minor. Footmarks of the United States, Plate IV., figs. 2, 3, p. 179.

[In the Cabinet, Nos. $\frac{20}{7}$, $\frac{21}{30}$, $\frac{39}{28}$, $\frac{16}{14}$, $\frac{19}{18}$, $\frac{37}{28}$, (bis).]

Hind Foot.—Tridactylous, pachydactylous; the toes terminated by blunt claws, or more probably pellets. Divarication of the lateral toes, 70°; of the inner and middle toe, 40°; of the middle and outer toe, 30°; axis of the foot turning towards the median line rarely over 5°. Length of the inner toe, 2.1 inches; of the middle toe, 2.5 inches; of

the outer toe, 2.5 inches; of the foot, 3.8 inches; of the step, right and left foot, 4.6 to 6 inches; do. left or right foot in succession, 13.5 inches. Number of phalanges in the inner toe, 2, with a claw or pellet equal in width to a phalanx; in the second toe, 3, and a pellet; in the third, 4 (?), and a pellet. Width of the toes, half an inch, often. From tip to tip of the lateral toes, 3.5 inches; from the inner to the middle, 2.4 inches; from the middle to the outer, 2.2 inches; middle toe longer than the others in front, 1.4 inch. Width of the trackway, 7.5 inches.

Fore Foot.—Divarication of the lateral toes, 66°; of the inner and middle toe, 35°; of the middle and outer toe, 30°; length of the inner toe from the middle of the heel, 2.7 inches; of the middle toe, 3.6 inches; of the outer toe, 2.7 inches. From tip to tip of the lateral toes, 3 inches; of the inner and middle toes, 3 inches; of the middle and outer toes, 2.2 inches; projection of the middle toe beyond the rest, 1.1 inch; width of the toes, 0.7 inch; phalanges not ascertained. Axis of the foot parallel to that of the hind foot, generally. Fore foot generally a little in advance of the hind one; sometimes on one side, and not unfrequently the two interfere.

An outline of these tracks is shown on Plate XVII., fig. 7. Two rows of them are also shown on Plate XXXV., figs. 1 and 2, copied from slabs in the Boston Society of Natural History. Plate XLV., fig. 5, shows a slab also from the Ichnological Cabinet containing several of these tracks, but not in regular order.

Locality.—This species was found by the late Dexter Marsh, at the quarry lying on the north side of the ferry at Turner's Falls. I think it occurs also at the Lily Pond. The specimens in the Boston Society of Natural History were from the Ferry.

Species 2. Plesiornis pilulatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{13}{1}$, $\frac{35}{48}$, $\frac{35}{49}$, $\frac{16}{4}$.]

Hind Foot.—Tridactylous, leptodactylous, all the toes pointing forward. (Probably a short fourth toe pointing backward from the heel, as in the tetradactylous birds.) Divarication of the lateral toes, 70°; of the inner and middle toe, 35°; of the middle and outer toe, 35°; length of the inner toe from the centre of the heel, 1.3 inch; of the middle toe, 2.1 inches; of the outer toe, 1.5 inch; of the foot, 2.1 inches; of the step, right and left foot, 7.2 inches. Distance between the tips of the lateral toes, 1.5 inch; between the inner and middle toe, 1.1 inch; between the middle and outer toe, 1.1 inch. Extension of the middle toe beyond the rest, 1.1 inch. Toes narrow, scarcely more than the tenth of an inch in diameter, terminated by pellets of the size of small shot, and hence the specific name. With this exception the whole track exactly resembles that of a small narrow-toed bird. Width of the trackway, 2 inches.

Fore Foot.—Tridactylous, leptodactylous; exactly resembling the hind foot, except that it is smaller. Divarication of the lateral toes, 70°; of the inner and middle toe, 40°; of the middle and outer toe, 30°. Length of the inner toe, 0.8 inch; of the middle toe, 1.4 inch; of the outer toe, 1 inch; of the hind toe, or heel, 0.25 inch; of the foot, 1.4 inch. Distance between the tips of the lateral toes, 1.1 inch; between the inner and middle toe, 1.1 inch; between the middle and outer toe, 0.9 inch. Fore foot on the

tracks generally a little in advance of the hind one; sometimes a little to the side, and sometimes they interfere with each other. The axes of the two feet coincide almost exactly with the median line, and the animal walked nearly upon a right line.

An outline of these tracks is given of the natural size, on Plate XVII., fig. 8. A fine row of them is also shown on Plate XXXVI., fig. 4.

Locality.—Discovered by Mr. Field, at the Lily Pond quarry.

Species 3. Plesiornis æqualipes.

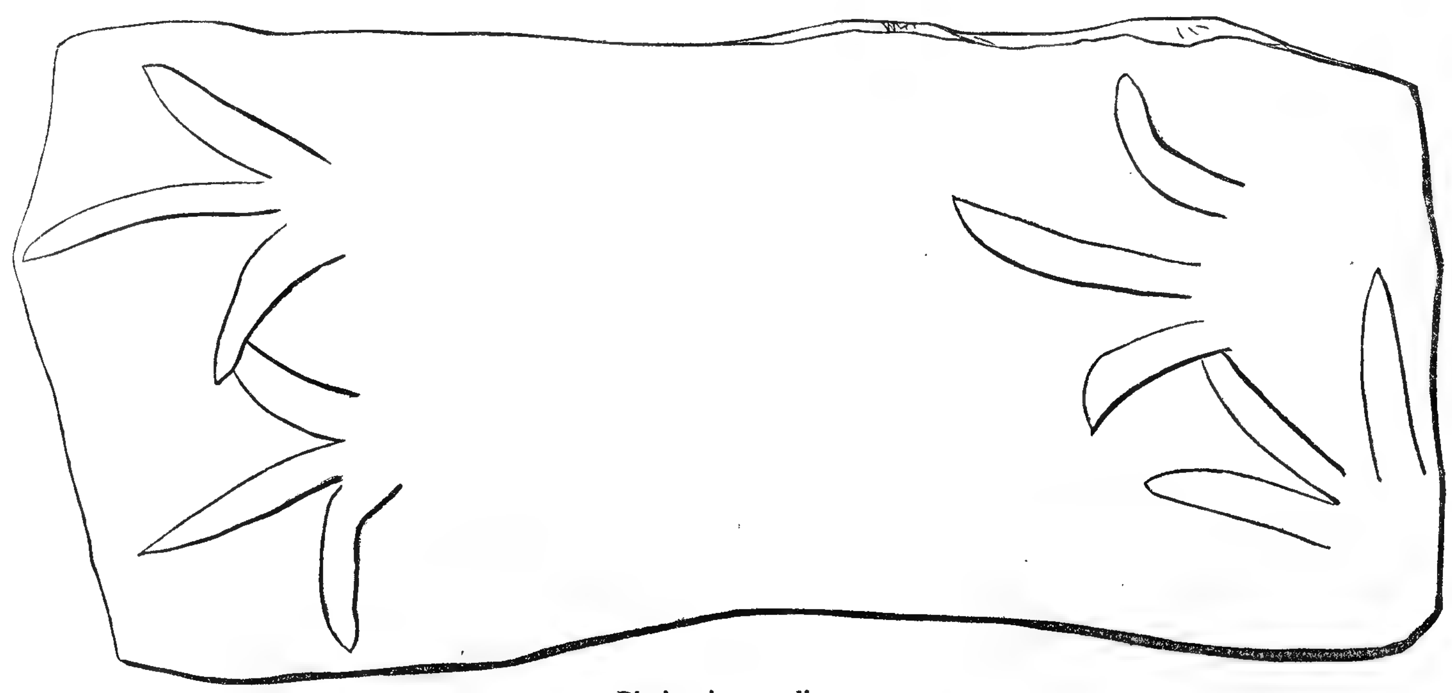
Ornithoidichnites minimus. Massachusetts Geological Report, Plate 15, fig. 41.

Argozoum minimum. Fossil Footmarks of the United States, Plate VI., fig. 6.

[In the Cabinet, Nos. $\frac{31}{7}$, $\frac{32}{37}$, $\frac{31}{79}$.]

Hind and fore feet nearly but probably not exactly equal. Toes three, directed forward. Divarication of the lateral toes, nearly 90°; of the inner and middle toe, 50°; of the middle and outer toe, 40°. Length of the middle toe, reckoning from the point where the toes meet, 1 inch; of the inner toe, 0.6 inch; of the outer toe, 0.7 inch; of the foot, so far as it impressed the mud at all, 1.1 inch; of the step, 3.2 inches; of the middle toe beyond the others, 0.5 inch. Distance between the tips of the lateral toes, 1.2 inch; between the inner and middle toe, 0.6 to 0.7 inch; between the outer and middle toe, 0.6 to 0.7 inch. Angle between the axis of the foot and the median line, sometimes 15°. Versed sine of the inward curvature of the inner toe, 0.1 inch; of the middle do., 0.75 inch; of the outward curvature of the outward toe, 0.05 inch. Feet digitigrade. Width of the trackway, 2 inches.

Remarks.—The specimens in the Cabinet are not sufficiently numerous to enable me to state the difference in size between the fore and hind feet, although, as the annexed wood-cut indicates, I think there is some difference. Hence the above description must answer for both.



Plesiornis æqualipes.

Until quite recently I have regarded the tracks of this species as those of a biped,—a narrow-toed bird. It was only recently that I noticed the juxtaposition of two similar tracks successively, as the wood-cut shows, and as is obvious on another specimen. The

great inward inclination of the lower left-hand track on the figure, has thrown some doubt on my conclusion as to the quadrupedal character of the animal; but the opposite evidence predominates. I had placed these tracks under Macropterna, and concluded not to give it in this Report. But a careful re-examination has reversed my decision, and I leave it under Plesiornis to be rejected or retained as future discoveries may indicate.

Locality.—On red shale, Wethersfield, and there only. When found, many years ago, I was not aware of any special interest attached to it, and did not, therefore, secure, as I might easily then have done, a good supply of specimens.

INCERTÆ SEDIS.

I mean by this phrase to indicate that the species to be described under it, I find very difficult to refer to any place among existing animals. I attach the Typopus to the ornithoid Lizards, or Batrachians, because some general resemblance seems to ally it loosely with those animals.

Genus VII.—TYPOPUS, (τύπος, type, and πούς, foot; because the track has some resemblance to the type of certain languages, especially the Oriental, and still more specifically, the Syriac.)

Heel spreading out laterally at right angles to the axis of the foot, and bent backward at one end; or perhaps with one or two hind toes proceeding from it. Front toes, three; the middle of the foot being arched upward, so that the middle toe in its posterior part rarely reaches the ground.

Remark.—Of the second species of this genus I have but one specimen, which, though very distinct, may be set aside in judging of its character. But several good specimens of the first species are in the Cabinet, and are very well characterized, and almost exactly alike, or I should be inclined to regard the track as a distorted representation of one made on a higher layer, and the impression carried through. Moreover, the rock is of that kind,—a hard micaceous sandstone,—that rarely admitted of much depth of impression. Again, there is a peculiarity in the position of some of these tracks, (to be described below,) that could hardly have been repeated, as it is, if this were not a veritable and nearly unchanged track. Under these circumstances, I can hardly do less than to describe the genus as well as I can; but it is so anomalous, that my description is lame and imperfect. I retain the same name which I gave it ten years ago. In all that interval no new light has been shed upon it.

Species 1. Typopus abnormis.

Sauroidichnites abnormis. American Journal of Science, Vol. XLVII.; Plate 3, figs. 6, 7, 8.

Typopus abnormis. Fossil Footmarks of the United States, p. 212, Plate X., fig. 6.

[In the Cabinet, Nos. $\frac{19}{1}$, $\frac{19}{2}$, $\frac{19}{16}$, $\frac{19}{17}$.]

Divarication of the lateral toes, 35°; of the inner and middle toe, 20°; of the middle and outer toe, 15°. Length of the middle toe to the heel, 2.8 inches; of the inner toe,

1.3 inch; of the outer toe, 1.8 inch; of the part of the heel turned backward, 0.7 inch; of the part running across the foot, 2 inches; of the foot, 4 inches; of the step, 18 inches; of the middle toe beyond the rest, 1.4 inch. Width of the heel where it turns backward, 0.25 inch; do. of the long ridge or heel from which the toes proceed, 2.2 inches. Distance between the tips of the lateral toes, 2.8 inches; between the inner and middle toes, 1.8 inch; between the middle and outer toe, 2 inches. Extension of the middle toe beyond the rest, 1.3 inch. Distance of the middle of the heel from the line of direction, 2.5 inches. Width of the trackway, 7 inches.

Outline of the track shown of the natural size on Plate XVII., fig. 9. Plate XLV., fig. 7, also shows a slab in the Cabinet, with one of the feet turned awry.

Locality.—At the ferry at Turner's Falls, where it was discovered by Dexter Marsh.

Remarks.—The singular fact (if I am not mistaken) that every other track turns aside from the line of direction 15° more than its alternate, on the specimens obtained cannot but awaken an inquiry as to the cause. I was once showing the specimens to an eminent Boston physician, and inquired of him how he could explain it. "The animal," he replied, "had its leg broken, and there were no good surgeons in those days to set it." This was just the reply I expected; since the same thought had been forced upon myself. What probability there may be in it, I must leave others to decide. But I have no other hypothesis to suggest.

Species 2. Typopus gracilis. (Nov. Sp.)

Figured but not named in the Fossil Footmarks of the United States, Plate 15, fig. 4.

[In the Cabinet, No. $\frac{31}{46}$.]

Three toes pointing forward, the two outer ones curving outward, with a versed sine of curvature equal 0.2 inch, and the third curving inward rather less. Heel an inch long, lying at right angles to the axis of the foot, and only the tenth of an inch wide. From the left hand extremity the heel seems to curve downwards at right angles, extending 0.6 inch, and terminating in a sharp point like a toe, and not improbably it is a toe. At the other extremity, also, the heel is acuminate, and has the aspect of a hind toe; so not improbably this is a five-toed track; very probably it may show the impression below where the animal trod, and be somewhat distorted. Outline shown of the natural size (nearly 2 inches long, without the curvature or hind toe at the end of the heel) on Plate XVII., fig. 10.

Locality.—On the red shale of Wethersfield Cove. As this is the only locality, and I have only one specimen from thence, I have but little confidence in this species. I shall expect at least, that both the species of Typopus will turn out to be quadrupeds; for with all their anomalies their tracks have a sort of lacertilian or batrachian aspect, to one familiar with the feet of animals. Therefore I place them under this Group.

Affinities of the Group.

Perhaps I have sufficiently indicated these under each genus. The name of the Group conveys the impression made upon my mind by the mixed characters of the

species. The ornithic type runs through them all, and seems specially manifest in the hind feet; but in Plesiornis it is not limited to the hind feet. Here and in the Hyphepus, perhaps, we find the Batrachian type decidedly developed; especially in the webbed and pelletted toes. But the fore feet of the Corvipes, Tarsodactylus, and Apatichnus, and the tail in some of them, look more like the lizard tribe. As to the Gigantitherium,—that most marvellous of the ancient races,—my mind is balanced on the question, whether the batrachian or lacertilian type predominated. The thickness of most of the toes looks batrachoid; but the claws and tail are lacertilian; though we ought not to forget that there may be frogs, or rather *are* frogs, with claws. (See Plate VI., fig. 11.) The foot, as a whole, with perhaps the exception of the curvature of the hind toe, is ornithoid; while the progression in a right line is decidedly quadrupedal. What shall we say of such a giant, combining perhaps the characters of most of the vertebrate kingdom; especially if, as yet appears, he was a biped! What being has been brought to light on the globe, or I might almost say in the dreams of mythology, more extraordinary than this ancient inhabitant of Massachusetts!

GROUP V.—LIZARDS.

Remarks.—The characters by which I would distinguish true lizards from some batrachians are not very trenchant and decided. I trust chiefly in a sort of slenderness and *lithiness* to designate the lizard. The number of toes, also, ought to be five in most instances, except in the fore feet of the Crocodilia. When, also, I see a long heel in the track it is a presumption of a lizard origin.

In a few of the species that follow, I have obtained no certain evidence that the animal had more than two feet. But such is the aspect of the track, as to lead me unhesitatingly to presume that it had a lacertilian origin.

Genus I.—POLEMARCHUS, (πολέμαρχος, Polemarch, a leader in war.)

Heel large and rounded, nearly as wide as the spread of the front toes. Three narrow, lithy toes, directed forward. The fourth toe a spur from the heel, inward. Foot plantigrade, or even calcigrade, the heel sinking deeper than the toes.

Remark.—This description is derived solely from the tracks of the hind foot, the fore foot, which I doubt not existed, not having been discovered, probably because a surface large enough to show the fore track was not got out: at least I did not see it. But the animal that made such a track as the one I am describing, must have been a reptile, and, therefore, probably four-footed.

Species 1. Polemarchus gigas.

Sauroidichnites Polemarchius. Massachusetts Geological Report, Plate 35, fig. 17.

[In the Cabinet, Nos. $\frac{26}{15}$, $\frac{26}{16}$, $\frac{26}{17}$.]

Hind Foot.—Divarication of the lateral toes, 45°; of the inner and middle toe, 20°; of the middle and outer toe, 25°; of the middle and hind toe, 80°. Length of the middle

toe to the heel, 11.2 inches; of the inner toe, 8.5 inches; of the outer toe, 8.3 inches; of the hind toe, 2.5 inches; of the heel, 3.8 inches; of the middle toe beyond the rest, 3.2 inches; of the foot, 14.8 inches; of the step, 48 inches. (?) Width of the heel, 3.9 inches; of the toes, 0.5 inch. Distance between the tips of the lateral front toes, 6.6 to 8.7 inches; between the inner and middle toe, 4 to 4.6 inches; between the middle and outer toe, 5.5 to 7.5 inches; between the middle and hind toe, 13 inches. Hind toe straight, acuminate; the others curved inward. Versed sine of curvature in the inner toe, 0.45 inch; in the middle toe, 0.9 inch; in the outer toe, 0.3 inch. Width of the trackway, 12 inches. (?) Track shown of its natural size on Plate XVIII., fig. 1. Also an ambrotype sketch on Plate LIX., fig. 3.

Fore Foot.—Not discovered.

Locality.—Chicopee Falls, in the middle of the river, directly upon the falls, just above the bridge; where a few years ago some blasting was done in very low water. Also in a quarry one mile south of Chicopee, (Cabotville,) on the road to Springfield.

Remarks.—I might perhaps have been justified in bringing this extraordinary animal into the family of Crocodilia, distinct from the general Group of lizards. For if I have described the hind foot, it has four toes like the crocodile, and a broad heel also. I can, however, discover no web to the toes, nor are those of the crocodile so long relatively. Still, if the fore foot should be found five-toed, as I confidently expect, the analogies will be rather striking.

Genus II.—PLECTROPTERNA, (*πλῆκτρον*, a spur, and *πτέρνα*, a heel, meaning, a spurred heel.)

Plectropus, of Fossil Footmarks, Plate IX., figs. 2, 3, and X., figs. 1 to 3.

Heel elongated, apparently extending in the track to the tarsal joint; narrow, spurred; foot calcigrade; toes four, three directed forward. Quadrupedal; fore and hind feet, of unequal size.

Species 1. Plectropterna minitans.

Sauroidichnites minitans. Massachusetts Geological Report, Plate 33, fig. 11.

Plectropus minitans and longipes. Fossil Footmarks of the United States, Plate IX., figs. 2, 3, and Plate VIII., fig. 4, and Plate X., fig. 1 to 3.

[In the Cabinet, Nos. $\frac{19}{6}$, $\frac{31}{9}$, $\frac{31}{21}$, $\frac{31}{82}$, $\frac{33}{22}$, $\frac{33}{23}$, $\frac{33}{24}$, $\frac{34}{11}$, $\frac{34}{12}$, $\frac{34}{13}$, $\frac{34}{14}$, $\frac{34}{30}$, $\frac{34}{31}$, $\frac{34}{35}$, $\frac{34}{38}$, $\frac{41}{30}$, $\frac{41}{31}$, $\frac{41}{32}$, $\frac{41}{35}$, $\frac{41}{36}$, $\frac{32}{28}$ (bis) $\frac{41}{46}$.]

Hind Foot.—Toes three in front and one on the heel, 1.4 inch back of the roots of the other toes. Divarication of the lateral front toes, 75°; of the inner and middle toe, 38°; of the middle and outer toe, 37°; of the middle and hind toe, 80°. Length of the middle toe from the roots of the toes, 4.8 inches: of the inner front toe, 3 inches; of the outer toe, 3.4 inches; of the hind toe, 1.4 inch. Toes narrow, pointed, Length of the heel, 4.3 inches; of the foot, 9.1 inches; of the step, 16 inches. From tip to tip of the lateral toes, 4 inches; of the inner and middle toe, 2.7 inches; of the middle and outer toe, 3.5 inches; of the middle and hind toe, 6 inches. Heel increasing in width backward and rounded; frequently also sloping upward posteriorly, as if the animal were not

wholly calcigrade. Lateral toes frequently somewhat curved outward, and the hind toe backward. Width of the trackway, 9 inches.

Fore Foot.—Track not discovered; but that of the next species has been, and a practiced eye cannot doubt the generic identity of the two; so that we may safely presume the fore foot of this species to be five-toed.

Outline of the hind tracks shown on Plate XVIII., fig. 2. On Plate XIX., figs. 10, 11, and 12, is shown one of these tracks on successive layers, which has been described in my preliminary remarks. Figs. 3, 4, 5, show the same on another specimen.

Locality.—The most abundant locality of this species is at the Cove in Wethersfield. But it was found by Mr. MARSH also, a little below Turner's Falls.

Remarks.—There is considerable diversity in some of the characters of the hind foot of this species, and I formerly made two species out of it. But thinking it possible that all the diversities may be referred to a difference in the size of individuals making the tracks, I have united the former species under the specific name of *minitans*, from the threatening aspect which its foot must have assumed if used as a weapon of attack.

Species 2. PLECTROPTERNA GRACILIS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{21}{5}$, $\frac{22}{1}$, $\frac{32}{21}$, $\frac{33}{26}$, $\frac{34}{15}$, $\frac{34}{9}$, $\frac{34}{34}$, $\frac{41}{8}$, $\frac{41}{9}$, $\frac{34}{36}$, $\frac{35}{30}$.]

Hind Foot.—Tetradactylous, three toes pointing forward; lateral ones slightly curved outward; all narrow and acuminate. Divarication of the lateral front toes, 94°; of the inner and middle toe, 57°; of the middle and outer toe, 37°; of the middle and hind toe, 105°. Length of the hind toe, 0.6 inch; of the inner front toe, 1.1 inch; of the middle toe, 1.8 inch; of the outer toe, 1.5 inch; of the heel, 2 inches; of the foot, 3.8 inches; of the step, from right to left foot, 4 inches; same foot, 7 inches. From tip to tip of the outer front toes, 2 inches; between the inner front and middle toe, 1.5 inch; between the middle and outer toe, 1 inch; between the middle and hind toe, 2.2 inches; hind toe back of the others on the heel, 0.6 inch. Width of the trackway, 5 inches.

Fore Foot.—This seems to be considerably distorted on the few specimens in the Cabinet, and therefore an attempt to describe it as minutely as usual would be of little use. It is five-toed, four pointing rather forward, and one at right angles to the axis. The length is 1.8 inch; the heel being about as long as the other part of the foot. It is situated a little outside of the hind track, and about as much advanced.

An outline of both these tracks is given on Plate XVIII., fig. 3, of the natural size. It will be seen that it is a far more slender and smaller species than the P. minitans. Plate XLVIII., fig. 2, exhibits a row of the P. gracilis, but it is rather indistinct.

Locality.—This species occurs on the farm of Mr. FIELD at Gill, and I am not certain of any other locality.

Species 3. Plectropterna angusta. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{33}{38}$, $\frac{33}{39}$, $\frac{33}{40}$, $\frac{33}{41}$, $\frac{33}{42}$.]

Hind Foot.—Four-toed, three directed forward, the fourth a spur curved backward. Heel broad and tapering backward, rounded at the extremity. Divarication of the lateral front toes, 47°; of the inner and middle toe, 22°; of the middle and outer toe, 25°; of the middle and hind toe, 95°. Length of the hind toe, 0.7 inch; of the inner front toe, 2 inches; of the middle toe, 2.8 inches; of the outer toe, 1.8 inch; of the heel, 1.4 inch; of the middle toe beyond the rest, 1.25 inch; of the foot, 4.2 inches; of the step, 12 inches. Toes narrow, slightly curved, the lateral ones outward. From tip to tip of the lateral toes, 1.6 inch; between the inner front and middle toe, 1.3 inch; between the middle and outer toe, 1.7 inch; between the middle and hind toe, 3.5 inches. Axis of the foot nearly coincident with the line of direction. Animal walking nearly upon a right line, as may be seen from Plate XXXVI., fig. 3, which is copied from a slab owned by Roswell Field. Width of the trackway, 2.7 inches.

Fore Foot.—Not yet discovered; and I am by no means certain that it ever will be; for though a certain general resemblance leads me to place this species under Plectropterna, it may be found that it is a bird. Its progression, so nearly in a right line, certainly agrees better with a bird than with a lizard, and its form scarcely differs from the bird type, especially if the species of Tridentipes already described were birds. But when so long a heel with a spurred toe lying nearly at right angles to it, exists, the aspect is so lacertilian that I have thought it safer to place such a species provisionally in that tribe, even though we find no marks of a fore foot where we should expect it; and we certainly should expect it on the fine specimen of Mr. Field's above referred to, only quite recently found on his farm.

An outline of the hind foot of this species is shown on Plate XVIII., fig. 4.

Species 4. Plectropterna lineans. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{42}$, $\frac{33}{45}$, $\frac{33}{46}$.]

Remark.—A resemblance, yet not as close as I could wish, between the specimen which I am about to describe from the red shale of Wethersfield Cove, and a row of tracks lately found by Roswell Field on his farm, has led me to erect this species. On Mr. Field's specimen only the hind foot is shown, and that arranged in the tracks so strikingly in a line, as to suggest the idea of moving in a right line for the specific name. Both tracks are shown on the Wethersfield specimen, and I think must come in under this genus, whether identical or not with the row figured on Plate XXXV., fig. 10, from Gill.

Hind Foot.—Tetradactylous, leptodactylous, toes all curved: the three front ones inward, and the hind one, which comes out from the heel at right angles, forward. Divarication of the lateral front toes, 67°; of the inner and middle toe, 25°; of the middle and outer toe, 42°; of the middle and hind toe, 63°. Length of the hind toe where it touched the ground, 0.5 inch; to the heel, 0.7 inch; of the inner front toe, 1.2 inch; of the middle

toe, 1.9 inch; of the outer toe, 1.1 inch; of the middle beyond the rest, 0.9 inch; of the heel, 0.7 inch; of the foot, 2.6 inches; of the step, 10 inches. Distance between the tips of the lateral toes, 1.1 inch; between the inner and middle toe, 0.8 inch; between the middle and outer toe, 1.2 inch; between the middle and hind toe, 1.9 inch. Width of the trackway, 1.4 inch.

Fore Foot.—Tetradactylous, leptodactylous, toes all curved inward, the two inner ones strongly; the versed sine equal to 0.15 inch, although the toe is only an inch long; the third scarcely curved at all; whole track an inch long, and 0.8 inch wide, placed somewhat in advance of the hind foot; the axis of both turning several degrees towards the median line.

Tracks shown of the natural size on Plate XVIII., fig. 5.

Genus III.—TRIÆNOPUS, (*τϱίαινα*, an anchor, and *πούς*, a foot; the anchor foot.)

Quadrupedal, tetradactylous on both fore and hind feet. Toes slender and long; three directed forward with small divarication. Fourth toe coming out near the extremity of a long heel.

Remark.—This genus occurs chiefly on the red shale of Wethersfield, and although the tracks are beautifully distinct, my specimens are so much broken and the tracks are so numerous, that I find it nearly impossible to determine which of them belong to the same animal. I formerly described two species. But I think it safer to reduce them to one in this Report. Yet I find it difficult to determine which is the hind and which the fore foot. It would not be strange if it should turn out that I have embraced not merely two species but two genera under one species.

Species 1. Triænopus leptodactylus.

Sauroidichnites Baileyi and Emmonsi. Massachusetts Geological Report, Plate 31, figs. 7 to 12, and Plate 32, figs. 8 and 9.

Triænopus Baileyanus, and Triænopus Emmonsianus of Fossil Footmarks of the United States, Plate X., figs. 4 and 5.

[In the Cabinet, Nos. $\frac{27}{8}$, $\frac{27}{9}$, $\frac{27}{10}$, $\frac{31}{23}$, $\frac{31}{24}$, $\frac{31}{25}$, $\frac{31}{26}$, $\frac{31}{27}$, $\frac{31}{28}$, $\frac{31}{29}$, $\frac{31}{30}$, $\frac{31}{35}$, $\frac{31}{36}$, $\frac{31}{37}$, $\frac{31}{38}$, $\frac{31}{39}$, $\frac{31}{40}$, $\frac{31}{41}$, $\frac{31}{42}$, $\frac{31}{45}$, $\frac{31}{48}$, $\frac{31}{49}$, $\frac{31}{50}$, $\frac{31}{55}$, $\frac{31}{58}$, $\frac{31}{76}$, $\frac{32}{31}$, $\frac{32}{32}$, $\frac{32}{33}$, $\frac{32}{34}$, $\frac{32}{35}$, $\frac{32}{36}$, $\frac{32}{47}$, $\frac{36}{7}$.]

Hind Foot.—(*Triænopus Baileyanus.*) Divarication of the lateral toes, 35° to 40°; of the inner and middle toe, 15° to 20°; of the middle and outer toe, the same; of the middle and hind toe, 30° to 40°. Length of the middle front toe, 2.5 to 3.6 inches; of the inner toe, 1.6 to 2.2 inches; of the outer toe, 2 to 2.5 inches; of the hind toe, 0.7 to 0.9 inch; of the heel, 1.4 to 2 inches; of the foot, 4 to 4.9 inches; of the step, 7 inches (?); of the middle toe beyond the others, 1.5 inch. Width of the foot at the roots of the toes, 0.3 inch; of the heel, 0.2 inch. At the extremity of the heel, or at the tarsal joint, there seems to have been an arch into which the mud was crowded as the animal trod, producing a small ridge, and beyond this backward, we sometimes find a depression seemingly made by a fifth toe, or by a part of the tibia. See Plate XIX., figs. 6 and 7,

where the dotted lines will give some idea of these appearances. Width of the trackway, 2.5 inches.

Fore Foot.—(*Tricænopus Emmonsianus*, Fossil Footmarks of the United States, Plate X., fig. 5.) Toes four; three pointing forward. Divarication of the lateral front toes, 50°; of the inner and middle toe, 25°; of the middle and outer toe, 25°; of the middle and hind toe, 115°. Length of the hind toe, which proceeds from the end of the heel, 0.7 to 1 inch; of the inner front toe, 1.5 to 2 inches; of the middle toe, 2.3 to 3.2 inches; of the outer toe, 1.5 to 2.2 inches; of the heel, 0.3 to 0.7 inch; of the foot, 2.8 to 3.9 inches. Distance between the tips of the lateral toes, 1.5 to 2 inches; of the inner and middle toe, 1.1 to 1.8 inch; of the middle and outer toe, 1.3 to 2 inches; between the middle and hind toe, 2.9 to 4.1 inches. Heel, 0.2 inch wide; at the roots of the front toes, 0.4 inch. Versed sine of the inward curvature of the inner toe, 0.15 inch; of the middle toe, 0.1 to 0.15 inch; of the outer toe, outwards, 0.05 inch.

Tracks of both feet shown of the natural size on Plate XIX., figs. 1 and 2. Figs. 3, 4, 5 and 6, show one of these tracks on successive layers; and figs. 6, 7, 8 and 9 the same on another specimen, and Plate XX., figs. 1, 2 and 3 a third, as described in my preliminary principles. Plate XLV., fig. 8, exhibits an ambrotype sketch of a fine specimen of these tracks from Wethersfield, No. $\frac{31}{27}$. Plate LII., fig. 1, exhibits the stony volume, No. $\frac{27}{9}$.

Genus IV.—HARPEDACTYLUS, (ἅρπη, a sickle, and δάκτυλος, a toe.)

Quadrupedal; tetradactylous, leptodactylous; heel long; toes generally all curved inward, so as to resemble sickles.

Species 1. Harpedactylus gracilis.

Sauroidichnites tenuissimus (?). Massachusetts Geological Report, Plate 34, fig. 13.
Harpedactylus gracilis. Fossil Footmarks of the United States, Plate XIV., fig. 2.

[In the Cabinet, Nos. $\frac{27}{18}$, $\frac{41}{50}$, $\frac{27}{11}$, $\frac{27}{14}$, $\frac{31}{13}$.]

Hind Foot.—Toes all pointing forward. Divarication of the outer front toes, 100°; of the inner and middle toe, 50°; of the middle and outer toe, 50°; of the middle and hind toe, 65°. Hind toe coming out of the heel only a little behind the roots of the others. From tip to tip of the toes, commencing with the inner or hind toe, and passing outward, 1.2, 1.5, 1.3 inch. Length of the toes in the same order, 0.9, 1.3, 2.1, 1.6 inches. Toes narrow, acuminate, all curved inward. Versed sine of curvature in the order above named, 0.0, 0.1, 0.15, 0.15 inch. Length of the heel from the roots of the front toes, 2.2 inches. Width of the same, 0.2 inch. Extension of the middle toe beyond the others, 0.9 inch. Toes curved inward towards the median line, but the axis of the foot nearly parallel to that line; the heel 0.9 inch distant. Length of the step, alternate foot, 3.5 inches; right feet or left feet, 3 inches. Width of the trackway, 5 inches.

Fore Foot.—Too imperfectly shown on any specimen to be minutely described; whole length 1.1 inch, including a heel about 0.25 inch long. Toes four, at least, more or less curved. Position of the foot very near the point of the middle toe of the hind foot, sometimes interfering with the toe.

Outline of the feet of natural size shown on Plate XX., fig. 4. Plate LII., fig. 5, shows, also, two hind feet very close together on the stony volume, No. $\frac{27}{18}$. The animal in this case stepped only an inch.

Localities.—The best locality is on gray shale, a little below Turner's Falls, in a quarry laid open by Dexter Marsh.

I have probably one or two other species of this genus, one from the red shale of Wethersfield, and described by me formerly under the name of Sauroidichnites tenuissimus; but as the specimens are not very distinct, I judge it best to describe only one species.

Genus V.—XIPHOPEZA, (ξίφος, a sword, and πέζα, a foot.)

Feet unequal; hind foot with a heel expanding posteriorly. Three toes directed forward with a hind toe on a prolongation backward of the outer toe; the whole foot resembling several swords or daggers crossing one another.

Species 1. Xiphopeza triplex.

Xiphopeza triplex. Fossil Footmarks of United States, Plate XV., fig. 8.

[In the Cabinet, Nos. $\frac{27}{10}$, $\frac{27}{11}$, $\frac{27}{13}$, $\frac{27}{14}$, $\frac{39}{6}$, $\frac{39}{8}$, $\frac{41}{26}$, $\frac{41}{51}$.]

Hind Foot.—Tetradactylous, three toes directed forward. Divarication of the lateral front toes, 80° to 90°; of the inner and middle toe, 40°; of the middle and outer toe, 50°; of the middle and hind toe, 130°; of the hind and outer toe, 180°. Length of the inner forward toe, 0.8 inch; of the middle toe, 1.5 inch; of the outer toe, 1.1 inch; of the hind toe, 0.5 inch; of the heel, 1.2 inch; of the foot, 2.6 inches; of the step, from hind foot to hind foot on alternate sides, 4 inches; do. on the same (right or left) sides, 7 inches. Greatest width of the heel near its extremity, 0.45 inch; do. near the roots of the toes, 0.2 inch. Distance from tip to tip of the lateral toes, 1.5 inch; between the inner and middle toe, 1 inch; between the middle and outer toe, 1.1 inch; between the middle and hind toe, 2.8 inches. Axis of the foot nearly parallel to the line of direction; distance of the axis from the median line, 1.1 inch. Width of the trackway, 4.5 inches.

Fore Foot.—Three toes on the specimens; probably four or five on the foot; less than an inch in length and breadth. Track just in advance of that of the hind foot.

Outline of both feet shown on Plate XX., fig. 6; also an ambrotype sketch of the stony volume, Nos. $\frac{27}{10}$ and $\frac{27}{14}$, on Plate LII., figs. 3, 4 and 6.

Locality.—At Turner's Falls below the dam, discovered by Dexter Marsh.

Remark.—This animal must have had a body of considerable width, as its feet were placed, in walking, more than two inches apart.

Genus VI.—ORTHODACTYLUS, (ὀρθός, straight; and δάκτυλος, a toe.)

Hind and fore feet unequal in size and unlike in form; the hind foot having at least four long, strait, and nearly parallel toes, and the fore foot four (probably five) short, radiating toes.

Species 1. Orthodactylus floriferus. (Nov. Sp.)

Figured, without name, by Dr. Deane, in the Journal of the Academy of Natural Sciences, Vol. 3, Plate 19, Diagram A.

[In the Cabinet, Nos. $\frac{6}{1}$, $\frac{29}{6}$.]

Hind Foot.—Toes four, all pointing forward. Divergence of the outer toes, 170° to 180°. The others make about an equal division of the arch, that is 45°, between each pair. Foot digitigrade. Length of the inner toe, 0.6 inch; of the second, 0.8 inch; of the third, 0.85 inch; of the fourth, 0.7 inch; of the step, right and left feet, 1.8 to 2.5 inches; between the hind foot and hind foot on the same side, 2.9 to 3.2 inches. From tip to tip of the lateral toes, 0.5 inch. Width at the roots of the toes, 0.4 inch. Angle of the axis of the foot with the median line outward, 35° to 40°. Distance of the middle of the heel from the median line, 0.3 to 0.9 inch. Width of the trackway, 3.25 inches.

Fore Foot.—Pentedactylous, digitigrade toes of nearly equal length are ranged on nearly a semicircle whose radius is about 0.4 inch. Track placed near the outer extremity of the hind foot, sometimes interfering with the hind toes, and looking like a stellate flower on four stalks, and hence the specific name.

Outline of the feet of natural size shown on Plate XX., fig. 7.

Locality.—Turner's Falls, Lily Pond, where it was discovered by Mr. Field.

Remark.—As the feet of this species, especially the hind feet, are digitigrade, it may turn out that the hind foot has five toes as well as the front one.

Species 2. Orthodactylus intro-vergens. (Nov. Sp.)

[In the Cabinet, No. $\frac{34}{32}$.]

Hind Foot.—Toes three, (probably four,) straight, from an inch to an inch and a quarter long, very narrow. Outer ones diverging a few (rarely more than 20°) degrees. Axis of the foot turned inward usually, a few degrees towards the median line, sometimes parallel to it. Length of the step, with the same hind foot, about 2 inches. Width of the trackway, 3.5 inches.

Fore Foot.—Of four, perhaps five toes, narrow, somewhat curved; about half the length of the hind foot. Axis turned considerably towards the median line. Tracks placed near the tips of the hind toes.

Outline sketch of the feet shown on Plate XX., fig. 8. An ambrotype sketch of the slab $\frac{34}{32}$, is also given on Plate LI., fig. 1.

Locality.—Turner's Falls, Lily Pond, at Mr. Field's quarry.

Remark.—My specimen for describing this species is not very satisfactory, as it shows the tracks a little below where the animal trod. But the great difference as to the position of the axis of the foot and the median line between this and the first species precludes the idea that they are the same; the toes in the first species turning a good deal outward, and inward in the latter species.

Species 3. Orthodactylus linearis. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{27}{5}$, $\frac{27}{15}$.]

Hind Foot.—Tetradactylous; toes narrow, lying nearly parallel to one another, with a divergence of the outer toes not over 20°. Toes increasing in length outwardly, except perhaps the last; the longest never over 0.5 inch. Divergence outward of the axis of the foot from the median line, not over 20°. Distance of the middle of the heel from the median line, from 0.2 to 0.5 inch. Length of the step, reckoning from step to step of the same foot, 1.2 to 1.8 inch. Right and left feet alternating. Toes dragging occasionally. Trace of a tail. Width of the trackway, 1.5 inch.

Fore Foot.—Apparently much in shape like the hind foot, though more slender; but the specimens are too indistinct to allow of a detailed description.

Outline of the hind feet and traces of feet and tail, of the natural size, on Plate XX., fig. 9. Also an ambrotype sketch of the whole slab, No. $\frac{27}{15}$, on Plate XLVIII., fig. 4. This is one leaf of a stony volume.

Locality.—Turner's Falls, Field's farm, discovered by Dexter Marsh.

Genus VII.—ANTIPUS, (ἀντί, opposite, and πούς, foot.)

Feet four and five-toed, pointing in nearly opposite directions.

Species 1. Antipus flexiloquus. (Nov Sp.)

[In the Cabinet, Nos. $\frac{35}{25}$, $\frac{41}{52}$.]

Hind Foot.—Tetradactylous, narrow, essentially plantigrade; toes acuminate; outer ones diverging at an angle of 65°; all pointing backward, and somewhat outward. Length of the inner toe, 0.8 inch; of the second, 1 inch; of the third, 1.1 inch; of the fourth, 1.1 inch; of the step by the same foot, 1.5 to 3.3 inches. Width from tip to tip of the lateral toes, 1 inch. Distance between the axes of the hind feet, 2.3 inches; angle of the same with the median line outward and backward, 20°. Width of the trackway, 5 inches.

Fore Foot.—Pentedactylous; toes very narrow, essentially plantigrade. Axis of the foot turned outward from the median line, from 50° to 70°. Divarication of the outer toes, nearly 180°. Two outer toes curved outward, the rest nearly straight. Length of the outer toe, 0.4 inch; of the fourth, 0.6 inch; of the third, 0.65 inch; of the second, 0.8 inch; of the first, 0.6 inch. Distance between the heels, 2.4 inches; from the median line, 1.2 inch.

Outline of these tracks shown of the natural size on Plate XX., fig. 10.

Locality.—Turner's Falls, on Mr. Field's farm, I believe at Lily Pond.

Remark.—It is not an infrequent occurrence for lizards, as well as Chelonians, and perhaps some Salamanders, to place their feet in walking as we find in this species. See a sketch of the Salamandra Beechyi on Plate VI., fig. 12. I speak of this species as ambiguous, (flexiloquus,) because I hardly know to which of these families to refer it.

I do not put it among the Salamanders because they have only four front toes and five hind toes; which order in this species is reversed according to our present knowledge. And the slenderness of the toes agrees better with lizards than Chelonians.

Species 2. ANTIPUS BIFIDUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{23}{2}$, $\frac{23}{3}$, $\frac{17}{2}$.]

Hind Foot?—Didactylous; outer toe, 7 inches long; inner toe, 12 inches. Width, 1.25 inch; blunt. Angle between them, 20°. Toes seeming like a simple bifurcation of the heel. Fore feet and hind feet pointing in almost exactly opposite directions. Distance between them, 8 inches. Trace of a narrow tail on the inner or left hand side of the tracks. Width of the trackway, 11 inches.

Fore Foot?—Inner toe, 5 inches long; outer toe, 12 inches; angle between them, 15°; width of the toes, 1.25 inch. Toes blunt.

I have not given an outline sketch of this species of the natural size, as I feel in so much doubt about its character. But Plate XXXVI., fig. 8, shows an outline sketch of the best specimen in the Cabinet, No. $\frac{23}{2}$. Fig. 7 of the same Plate shows a specimen (No. $\frac{17}{2}$,) which I connect with this species, although all it shows is a heel 14 inches long and 2 inches wide, with the trace of a strong tail, sweeping to the right and left in a serpentine course. At one end, however, the heel expands just where the slab terminates, but whether it divides into two or three toes I cannot ascertain. I doubt whether this track and that of Antipus bifidus are the same; but let them stand together till better specimens are found. I have had these specimens in my possession for a long time; but have waited in vain for light. I cannot satisfy myself even which was the hind and which the fore foot, and am in doubt whether the bifurcation described was made by toes or something else. The impressions being of equal size throughout do not resemble toe tracks, but rather long heels. Plate XLVIII., fig. 10, shows an ambrotype sketch of No. $\frac{23}{2}$.

Locality.—Turner's Falls, at the Ferry, where the specimens were found by DEXTER MARSH.

Remarks.—Perhaps I have not sufficiently indicated the impressions produced on my mind by the specimens of Antipus bifidus described above. No. $\frac{23}{2}$ seems to me to be the fore and hind feet, pointing in opposite directions, of one side of an animal, with a tail trace on one side. Had we the slab on the other side of this trail, probably we should find another set of similar feet. But of this we cannot be sure.

GENUS VIII.—STENODACTYLUS, (στενός, slender, and δάκτυλος, a toe.)

Both feet (hind and fore) pentedactylous, very slender and lithy.

Species 1. STENODACTYLUS CURVATUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{34}{30}$, $\frac{33}{11}$, $\frac{33}{20}$, $\frac{33}{21}$, $\frac{35}{29}$, $\frac{39}{5}$.]

Hind Foot.—Toes all curved outward from the median line, except the short outer one. Outward angle between the axis of the foot and the median line, about 20°.

Distance of the heel from the median line, 0.6 inch. Divergence of the toes exclusive of the short outer one, 70°. Length of the toes, commencing with the inner one, 0.7, 0.8, 1, 0.85, 0.25 inch. Versed sine of the curvature of the first four toes, beginning with the inner one, 0.1, 0.15, 0.18, 0.1 inch. Length of the foot, 1 inch; of the step, with the same foot, 3.3 inches. Width of the trackway, 2.5 inches.

Fore Foot.—Axis of the foot curved outward nearly at right angles with the median line. Distance of the heel from the median line, 0.6 to 1.1 inch. Length of the toes from within outwards, 0.25, 0.3, 0.5, 0.55, 0.1 inch. Inner and outer toes pointing nearly opposite; third and fourth considerably curved outwards. Fore foot placed rarely less than an inch in advance of the hind foot.

Outline of both feet in their usual position shown on Plate XX., fig. 11. A sketch of the whole slab, $\frac{34}{30}$, shown on Plate XXXIV., fig. 3; one of the feet being represented by dots, because a good deal broken.

Locality.—Turner's Falls, on Mr. Field's farm.

GENUS IX.—ARACHNICHNUS, (ἀράχνης, a spider, and ἴχνος, a track; i. e. a track looking like a spider.)

Remark.—Four or five-toed, the toes radiating in all directions, especially on the hind feet. Lines also diverge from the track longer than the toes, in two and sometimes three directions, which are acuminate like the toes, but evidently not toes.

Species 1. ARACHNICHNUS DEHISCENS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{40}{12}$, $\frac{40}{13}$, $\frac{40}{11}$, $\frac{40}{15}$, $\frac{40}{62}$.]

Hind Foot.—Pentedactylous, narrow; the inner and outer of the four front toes pointing exactly opposite. Length of the toes beginning with the inner hind toe and proceeding outwardly by the inner front toe, 0.5, 0.4, 0.65, 0.4, 0.35 inch. Radiating lines connected with the track rarely more than an inch long, and more frequently coinciding with the axis of the foot. Axis of the foot usually nearly parallel to the median line. Distance between the rows of tracks on opposite sides of the animal's body, 2.3 inches. Length of the step from footprint to footprint of the same foot, 3 to 4.5 inches. Width of the trackway, 3 inches.

Fore Foot.—Tetradactylous (probably five-toed); toes radiating through a semicircle, nearly equal in length, or about a quarter of an inch. Track just in advance of, though frequently interfering with, that of the hind foot.

Outline of the tracks of natural size shown on Plate XX., fig. 12; fig. 13 also shows a hind foot with the radiating lines proceeding from it. Plate XXXVII., fig. 2, shows a slab of these tracks on a reduced scale, where the animal made sudden turns in his course. ($\frac{20}{12}$.)

Locality.—At the Lily Pond, discovered like all others at that locality by Mr. FIELD. On rather soft, slightly reddish shale.

Remark.—The difficulty of explaining the radiating lines connected with all the tracks of this species, I have seen, with perhaps one or two exceptions, led me to give it

the specific name of *inexplicabilis.* But recent examination of other localities, especially at Middletown and Portland in Connecticut, have led me to the conclusion that these marks are *sun cracks*, which were afterwards filled with mud. I at first suspected that they might have resulted from the dragging of the animal's feet; but the fact that they always become narrower outward, though proceeding in various directions, cuts off such a supposition. But this would be natural, if cracks in the sun-dried surface proceeded outward from a track. In most other cases which I have noticed, these mud crack veins proceed from the tips of the toes, but not always in the Arachnichnus. They would most naturally follow the prolonged direction of the toes, but not necessarily; as may be seen finely illustrated on that beautiful slab represented on Plate LX., fig. 1.

Of all places which I have ever visited, the Portland quarries are the best for studying the phenomena of sun cracks and mud veins. I am convinced after recent examination, (November, 1857,) that the remarkable examples in the Appleton Cabinet from Portland, figured on Plate LVI., figs. 1 and 2, as well as fig. 3, from Turner's Falls, were produced by the action of the sun upon the mud and the subsequent introduction of mud by aqueous agency; though it is not easy to see how the edges of the inlaid pieces should have been so finely rounded and even smoothed.

Genus X.—CHIMÆRA, (*Χίμαιρα*, the name of a fabulous monster.)

Four toes, with a stout heel behind, and five before. Tail broad and stout.

Remark.—In this genus we have a repetition of the facts detailed, when describing the Apatichnus circumagens. For in the Chimæra, also, we find on the upper surface a distinct tail and indistinct tracks, with a rather long heel on the hind foot. But on splitting off a layer one inch thick, while the tail and the long heel and generally the fore foot also, have disappeared, a more distinct impression is presented of the four toes, apparently radiating from a rounded heel. For my views as to the manner in which these phenomena were produced, I would refer to the description already given of the Apatichnus. It is possible that the Chimæra may turn out to be identical with the Apatichnus. But the much greater breadth of the tail in the latter genus, and the great differences between the feet both before and behind, forbid me, as I now view the characters, to bring them together. The ornithoid aspect of the hind foot of the Apatichnus is striking; but that of the Chimæra is strongly lacertilian, approaching, however, the batrachian type in the fore foot.

Species 1. Chimæra Barratti.

Anomœnus Barratti. (?) Fossil Footmarks of the United States, Plate 13, fig. 3.

[In the Cabinet, Nos. $\frac{13}{2}$, $\frac{20}{4}$, $\frac{31}{14}$, $\frac{37}{9}$, $\frac{37}{10}$.]

Hind Foot.—Four-toed; three toes directed forward; heel long. Divarication of the inner forward toes, 75°; of the inner and middle toe, 37°; of the middle and outer toe, 40°; of the middle and hind toe, 65°. Length of the toes in order outward, commencing with the hind toe, 1.2, 2.5, 3.8, 2.7 inches; of the heel, 3 inches; of the

middle toe beyond the others, 1.75 inch. Distance between the tips of the lateral toes, 3.3 inches; between the inner and middle toe, 2.3 inches; between the middle and outer toe, 2.3 inches; between the middle and hind toe, 4 inches. Length of the foot, 6.9 inches; of the step of the same hind foot, 18 to 20 inches. Toes thick, heel thick and rounded at the end. Tail making a pathway an inch broad and somewhat crooked. Distance between the rows of tracks, 6 inches; axis of the hind foot turning outward from the median line from 15° to 25°. Width of the trackway, 9 inches.

Front Foot.—Five-toed; toes thick, rounded and curved inward; divarication of the outer ones, nearly 180°. Length of the toes from the centre of the heel, reckoning outward, 1.1, 1.7, 1.8, 1.5, 1.3 inch. From tip to tip in the same order, 0.7, 0.7, 1, 1.4 inch. Greatest *length* of the foot, 1.65 inch; *breadth* of the same, 2.5 inches. Position of the front foot in relation to the hind one, irregular.

Outlines of these tracks are shown on Plate XXI., fig. 1, hind foot, fig. 2, fore foot. Fig. 3 is a hind foot, on a layer half an inch below that on which the heel of the hind foot and the tail left impressions. Fig. 4 may be the fore foot of this animal, from Marsh's quarry in Montague; yet it is quite unlike fig. 2, and very likely belongs to a different animal. Plate XXXVII., fig. 1, shows a row of these tracks, one-half of which exhibits a layer half or three-quarters of an inch below the other part, and shows how even that depth changes the aspect of a track, though more distinct than those on the layers where the animal trod.

Localities.—Turner's Falls, and perhaps Montague, at Marsh's quarry, and also Middletown.

Remarks.—I affix the name of my friend Dr. Joseph Barratt of Middletown to this species, as its discoverer, although I am not sure that the specimen which he pointed out to me in Middletown as the Anomœpus Barratti is the same. But I rather presume them to be identical.

Genus XI.—ISOCAMPE, (ἴσος, equal, and καμπή, a curve; referring to the almost equal curvature of the toes.)

Hind and fore feet of unequal size; the four toes in the hind foot all curved inward nearly alike. Animal digitigrade, caudate.

Remarks.—Recently (November, 1857,) I purchased of Dr. Joseph Barratt the specimen of which Plate XXXVI., fig. 5, is a reduced sketch, and which I recognized as new. It shows, however, only what I regard as the hind foot, with a trace of the tail. But on seeing it I was reminded of a small specimen in the Cabinet from Turner's Falls, which I have long observed, but have not felt prepared to give it a name. That specimen shows both feet, if I do not mistake, with a fourth toe on the hind foot, and at least that number in front. But although the Middletown specimen shows no one track so perfect, yet exhibiting a succession of tracks, made by one side of the animal, and a tail, it reveals the general characters of the species. But I shall venture to use the Turner's Falls specimen as the basis of my description of the individual tracks, and add others from the

Connecticut specimen. The generic name is founded on the almost equal curvature of the toes. The specific name following, represents the animal as sprawling.

Species 1. Isocampe strata. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{26}{4}$, $\frac{40}{63}$, $\frac{35}{20}$, $\frac{35}{21}$, $\frac{35}{22}$.]

Hind Foot.—Tetradactylous, pachydactylous; toes all curved inward, nearly of equal length, digitigrade. Toes nearly or quite parallel, so far as they impress the ground in walking. Versed sine of curvature in the outer toe, 0.15 inch; of the next toe inward, 0.4 inch; of the next, 0.3 inch; of the next, 0.25 inch. Length of the toes, commencing with the inner one and going outward, 1.65, 2, 2.3, 2.15 inches. Length of the step, from track to track of the same hind foot, 3.4 inches. Axis of the hind foot nearly parallel to the line of direction. Distance from the median line, 2.2 to 3.2 inches. Trace of the tail from 0.25 to 0.6 inch broad; crooked and irregular. Width of the trackway, 7 inches.

Fore Foot.—Tetradactylous; (five-toed ?) Toes nearly straight. Divergence of the outer ones, 35°; of the two inner ones less than 5°; of the second and third, 5°; of the third and fourth, 25°. Length of the toes, counting outwards, 1.1, 1.7, 1.2, 1.1 inch. Axis of the foot turned a little more inward towards the median line, than that of the hind foot. Position of the fore foot a little nearer the median line than, and in advance of, the hind foot.

Outline of the tracks of this species of the natural size given on Plate XX., fig. 5. Reduced outline of the slab from the Portland quarries on Plate XXXVI., fig. 5. This shows, if I understand it, a trace of a tail and tracks of the hind feet of one side of the animal. The row on the other side was broken off, as I suppose, before I saw the specimen.

Localities.—The Portland quarries, opposite to Middletown in Connecticut, are one locality as already named, and Turner's Falls another, if I have not misapprehended the specimens.

Affinities of the Group.

Perhaps I have given these sufficiently under the several genera. The number of toes, especially on the fore feet, which usually show five,—the slenderness and lithiness in general of the toes, the usual presence of a long heel,—and often of a tail, the diminutive size of the fore feet, and the position both of hind and fore feet when the animals walked, lead the mind, upon the whole, more strongly towards the lizards than any other tribe. Yet there are some anomalies and peculiarities that agree better with other families; and I have already spoken of the difficulty of distinguishing by their tracks, lizards and salamanders, excepting by the number of toes; which, in the fossil footmarks, is a most delusive character, because so difficult to be ascertained with certainty.

GROUP VI.—BATRACHIANS.

Genus I.—BATRACHOIDES, (βάτραχος, a frog, and εἶδος, form, or shape: resembling a frog.)

Remarks.—At a meeting of the American Association for the Advancement of Science, in New Haven, in 1850, Professor Benjamin Silliman, Jr., presented a paper on certain small spheroidal cavities in the Niagara Group of the New York rocks. He suggested that they might have been formed by tadpoles, as he and Dr. N. S. Manross had observed similar cavities to be formed by the gyratory movements of existing tadpoles.

Still earlier, Professor James Hall, in his Report on the Fourth District of New York, (p. 93,) described and figured these cavities, which he was disposed to regard as concretionary.

I was absent in Europe in 1850, and not happening to look over the Proceedings of the Scientific Association on my return, I brought forward the same subject at its meeting in Albany in 1856. The occasion, however, was the discovery of far more perfect and beautiful specimens in the red shale of South Hadley, in Massachusetts. These were brought to my notice by Paoli Lathrop, Esq., of that place, and by him I was assisted in obtaining the splendid specimens now displayed in the Ichnological Cabinet,—the most attractive, probably, of all the specimens there exhibited. Accidentally I discovered, in 1856, similar depressions in muddy places, made by living tadpoles in South Hadley. Hence I suggested before the Association in 1856, the same theory, and sustained it by the same facts, as did Prof. Silliman in 1850, not knowing that I was repeating his paper. But during the past summer (1857), I have had an opportunity to witness the phenomenon on a magnificent scale, in a hole, some fifteen or twenty feet deep, in Hadley meadows, close by the Northampton bridge over Connecticut River. In the spring the river flows into the hole and fills it, and it requires a large part of the summer for all the water to evaporate. A small species of frog (*Rana fluviatilis?*) chooses the place for depositing its eggs, which become tadpoles when the water is reduced to the depth of a foot or two feet. The bottom is then perhaps three rods long and two rods wide; and before the water is all evaporated, and the tadpoles change into frogs, (which they do about the time when the water fails,) the whole of this surface became covered with spheroidal cavities, which could not be distinguished from those on stone. The Senior Class of 1857 in Amherst College, who were familiar with the specimens on stone in the Cabinet, visited the spot, and were so struck with the appearance as to denominate the place, *Tadpole City*.[15]

I had been led to doubt the tadpole origin of the South Hadley and New York specimens, by the fact that in many cases the cavities were arranged in lines, and sometimes too it was clear that they occupied ripple marks. But I found the same thing at Tadpole City. Deep as the hole is, and slight as could be any aqueous current there, I found that ripple marks, of about the same width and depth as those on the rocks, had

[15] The present year, (1858,) I have met with a still larger number of these tadpole nests, affording still stronger confirmation of the views advanced in the text.

been formed over a part of the bottom, and of course the tadpoles chose the furrows rather than the ridges for making their holes. Another circumstance showed how their holes came to be arranged in lines more or less, even where there were no ripple marks. As the water became shallow, I found that the tadpoles would collect in great numbers just along the surface of the water, at its edge, and there of course would the work of excavation be most thorough. But as the water was constantly sinking, successive rows would thus be produced. In fact, until the rains destroyed this city, I could not see but all the phenomena on the rocks were reproduced. And I know that these cavities were formed by tadpoles, because I saw the animals at work in making them. And had the spot been so situated that a gentle influx of water, as by a tide, or a freshet, should bring in mud to fill the cavities before they were erased by the rains, they might have been preserved indefinitely; and perchance sometime be converted to rock, such as the South Hadley shale, or the Niagara sandstone. As it was, I succeeded in obtaining two or three specimens of the mud with the depressions, and by hardening the surface with glue, they have been transferred to the Cabinet, where (as Nos. $\frac{38}{8}$ and $\frac{38}{9}$) they lie by the side of the specimens on stone, and will afford naturalists an opportunity of judging whether I am justified in concluding that the fossil impressions were made by batrachians similar to those now living. I venture thus to regard them, till the contrary is proved: though by no means free from doubts as to the identity of the phenomena. For both concretion and aqueous action are by no means yet fully understood; and I know that their effects are often marvellous. I have some specimens, evidently the result of aqueous action, which approach in character what I call Tadpole Nests, though much less perfect. Some of these latter are regular hexagons, like the cells of bees, and exhibit the like concentric arrangement. Often the filling in of mud a quarter of an inch thick, was sufficient to obliterate all traces of the cavities, and then we find frequently another set superimposed, and then several others perhaps, to the thickness of several inches: indicating, if my views are correct, that the same spot was occupied successive years by the same species of batrachians, as we know mud holes now are.

These nests are not, properly speaking, tracks, if made by tadpoles. But they prove the existence of these animals, just as the tracks do of the animals by which they were formed. And, therefore, it is appropriate to name, and as far as we can, describe them. This I shall do, under the genus Batrachoides, already named. The descriptions, however, must be very brief.

Generic Character.—Animal a Batrachian, analogous to a species of Rana.

Species 1. Batrachoides nidificans. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{9}{1}$, $\frac{9}{3}$, $\frac{9}{6}$, $\frac{9}{7}$, $\frac{9}{15}$, $\frac{9}{12}$, $\frac{9}{13}$, $\frac{38}{5}$, $\frac{38}{6}$, $\frac{38}{7}$, $\frac{38}{11}$, $\frac{38}{12}$, $\frac{38}{13}$, $\frac{38}{14}$, $\frac{38}{15}$, $\frac{38}{17}$, $\frac{38}{18}$, &c.]

Animal forming rounded and sometimes polygonal cavities or nests in mud a little over an inch in diameter, and on the stone rarely more than the tenth of an inch deep, but evidently compressed vertically.

An outline of three of these nests is given on Plate XXI., fig. 5. Fig. 7 of the same Plate shows also three samples of the nests made in mud by living tadpoles. An

ambrotype sketch of a slab, No. $\frac{38}{14}$, in the Cabinet of B. nidificans is shown on Plate L., fig. 1, and figs. 3 and 4 show the same of the nests of recent tadpoles. (Nos. $\frac{38}{8}$ and $\frac{38}{9}$.) Fig. 1 gives a very accurate idea of these cavities.

Locality.—South Hadley, in an old abandoned quarry a mile above the Falls, on the north shore of Connecticut River, Also in the brook near Mount Holyoke Seminary.

Species 2. Batrachoides antiquior.

[In the Cabinet, Nos. $\frac{38}{10}$, $\frac{38}{25}$.]

Nests generally circular, sometimes elongated, scarcely an inch in diameter, yet deep.

Outline of three of these nests of the natural size, shown on Plate XXI., fig. 6, taken from No. $\frac{38}{10}$ of the Cabinet, An ambrotype sketch of the whole specimen, $\frac{38}{10}$, is given on Plate L., fig. 2.

Locality.—In shale or sandstone connected with the Niagara group of rocks in New York, which belongs to the Upper Silurian, at Lockport and south of Lockport.

Remarks.—If it be indeed true that the cavities in this rock were formed by tadpoles, then batrachians, analogous to those now on the globe, must have lived at that early period, a fact of which we have no other evidence in paleontology. But on recurring to Professor Hall's description just as I was finishing this account, (p. 92 of his Report,) I understood him as representing these capsules, which he calls little "knobs or incipient concretions," as having the convex side uppermost. If this be the case, they are quite different from the concavities on the South Hadley shale, which are always depressions, like the recent nests of tadpoles. If the New York specimens are pustules instead of capsules, then they belong to a different class of phenomena from those at South Hadley. Yet there is a striking resemblance in the hand specimens from the two localities. I hope that the preceding descriptions will at least excite the attention of geologists to this curious subject.

Genus II.—OTOZOUM, (Ὦτος, a giant, and ζῶον, an animal; a giant animal, or animal giant.)

Quadrupedal, four-toed behind, and five-toed before, web-footed, caudate,(?) toes thick, mostly terminated by pellets.

Species 1. Otozoum Moodii.

Otozoum Moodii. Fossil Footmarks of the United States, Plate XII., fig. 1.

[In the Cabinet Nos. $\frac{3}{1}$, $\frac{4}{1}$, $\frac{4}{2}$, $\frac{4}{3}$, $\frac{4}{4}$, $\frac{4}{5}$, $\frac{5}{1}$, $\frac{5}{13}$, $\frac{5}{14}$, $\frac{6}{3}$.]

Hind Foot.—Divarication of the lateral toes, 37°; of the inner and second toe, 25°; of the second and third, 4°; of the third and fourth, 11°. Length of the inner toe, commencing with the first phalanx, 8.5 inches; of the second toe, 8.5 inches; of the third. 7 inches; of the fourth, 7.5 inches; of the foot, 19 inches; including the web, 20 inches, Breadth of the phalanges of the inner toe, 2.2 inches; of the middle toe, 3 inches; of the third, 2.6 inches; of the fourth, 3 inches. Web extending some distance beyond the margin of the foot. Length of the step of the same foot, 30 inches to 51. Phalanges in

the three inner toes, three; in the outer toe, four. Length of the proximal phalanx of the inner toe, 2.7 inches; of the second do., 2 inches; of the third do., 2 inches; of the proximal phalanx of the second toe, 3 inches; of the second do., 2.7 inches; of the third do., 2 inches; of the proximal phalanx of the third toe, 2.5 inches; of the second do., 2 inches; of the third do., 2.2 inches; of the proximal phalanx of the fourth toe, 1.8 inch; of the second do., 1.5 inch; of the third do., 1.6 inch; of the fourth do., 1 inch. Length of the first bone behind the roots of the two outer toes, articulated to both, 4 inches; width of do., 5.5 inches. Length of the second metatarsal or tarsal bone behind, 3.3 inches; width of do., 4 inches; length of the third do., forming the extremity of the heel, 4.3 inches. Breadth of do., 4 inches. Length of the metatarsal or tarsal bone to which the two inner toes are articulated, 8 inches; width of do., 3.5 inches. Length of the pellet of the second toe, 2 inches; width of do., 1.5 inch; length of the pellet of the third toe, 1.5 inch; breadth of do., 1.5 inch; length of the pellet of the fourth toe, 2.3 inches; breadth of do., 1.5 inch. Do. of the incurved claw of the inner toe, 2 inches. Axis of the foot turned outward about 10° from the median line. Distance of the middle of the heel from the median line, 2.5 inches. Tail stout, yet rarely dragging on the ground. Width of the trackway, 26.5 inches.

Fore Foot. — Pentedactylous, pachydactylous; toes turned outward. Length of the first or hind toe having apparently but one phalanx, 2.5 inches; width of do., 2 inches; length of the second toe, 3 inches; apparently but one phalanx; length of the first phalanx of the third toe, 1.3 inch; of the second phalanx, including a claw half an inch long, 2.3 inches. First phalanx of the fourth toe, 1.7 inch; of the second phalanx, 1.8 inch; of the first phalanx of the fifth toe, 1.2 inch; of the second phalanx, 1.4 inch; of the third phalanx, 1.4 inch. Distance between the fore feet, 10 inches; right foot, on the only specimen in the Cabinet, is 6 inches in advance of the other. The position of one of these tracks is beneath the hind foot; a fact showing that the animal brought up its hind feet fully into the place just vacated by the fore feet in walking.

An outline sketch of the hind foot of this animal is given on Plate XXII.; the fore foot is shown on Plate XXIII., fig. 1, and a reduced outline of the slab, No. $\frac{5}{14}$, which contains the fore feet, is shown on Plate XLVI., fig. 5. This will show the exact position of the front feet, which will strike the careful observer at once as being very much like that of Anomœpus major and minor, and the shape of the fore foot is similar in all these species; but the hind feet are very diverse.

Plate XXXIII., fig. 4, represents a slab in the Cabinet, No. $\frac{5}{1}$, over 30 feet long, which has a row of eleven depressed hind-feet tracks of this animal, with a multitude of the tracks of the Brontozoum Sillimanium. By mistake the ninth track of this series got lost, and I substituted one in the vacancy obtained from another row, as the sketch indicates.

Fig. 5 of the same Plate shows a row of nine similar tracks of Otozoum, with a still larger number of small ones, all in relief, being No. $\frac{4}{1}$ of the same Cabinet. The three first tracks of this row, however, were not originally connected with the remainder; but were placed in the same row at the usual interval between the tracks; and it hardly

conveys any error to regard them as originally thus arranged since several rows discovered at the same locality scarcely differ. Plate XLV., fig. 2, is an ambrotype sketch of the front part of a hind foot from Turner's Falls, showing the web very distinctly extending beyond the toes.

Localities.— South Hadley, two miles north of the village, on the road to Amherst, is the most prolific locality of the tracks of this extraordinary animal. They were here revealed in a small quarry, opened almost in the highway, for other purposes; but in which excavations have been continued for scientific purposes. And as a row of the Otozoum tracks now lies uncovered in it, belonging, I believe, to Gilbert Smith, Esq., I thought it might be pleasant to have a sketch of it as a Frontispiece to this Report. For the sketch I am indebted to F. A. Lydston, Esq., of Boston, and the late Rev. Plinius Moody, of South Hadley.

Turner's Falls at the ferry is another locality of these tracks. From the small size of some of the specimens there, I have suspected that they were made by a second species; but my specimens are somewhat broken, and I leave it for others to decide this question.

A third locality is at the Portland sandstone quarries, opposite Middletown in Connecticut. A slab several feet long, belonging to the Middlesex Company, shows two of these tracks in relief, and a multitude of the Brontozoum Sillimanium, looking in fact like those from South Hadley, sketched on Plate XXXIII., figs. 4 and 5. From these quarries the fine specimen in Yale College was obtained, which is one of the best ever found. Another fine slab from the same quarries belongs to the Wesleyan University at Middletown, and it is only on one part of this slab that I have ever seen the trace of a tail belonging to this animal. It is possible that the trail may not have been thus made; but such was not my conclusion when looking at it.

Upon the whole, this animal appears to have been no stranger in the Connecticut Valley, since we find the traces of his abundant presence at the two extremities and in the middle of the great Ichnological Basin.

History.—It is interesting to observe what progress has been made in tracing out the character of the tracks of this species. The hind feet were first discovered by Pliny Moody, Esq., of South Hadley, in the quarry in front of his house, exhibited in the Frontispiece. As observed in another place, Mr. Moody was the first person, so far as I know, who discovered and preserved as objects of interest, fossil footmarks, near the beginning of the present century; and, therefore, when his neighbors were quarrying stone before his door, he noticed and secured several slabs, one of which he generously deposited in Amherst College; and from which I was enabled to make out my former descriptions of this animal. It seems highly proper, therefore, that I should affix his name to the species as its discoverer.

Until recently, however, the facts developed in the Moody Quarry as to this species showed only that it was a biped, with the right and left foot distinctly indicated, as it moved in several long rows over the surface. Not long after the publication of my first description of the animal, I discovered that all the toes, except the inner one, were

terminated by pellets, instead of claws; the inner one, as the outline on Plate XXII. shows, having a strong blunt incurved claw. Next I found that the animal was web-footed, the web extending, if I mistake not, beyond the toes, as in the Ornithorhynchus of New Holland, whose foot is shown on Plate VI., fig. 13. Recently, from a specimen owned by the Wesleyan University, I infer that the animal had a tail. But still more important, its fore feet have been discovered and pointed out to me by the late Rev. PLINIUS MOODY, son of the original discoverer. This gentleman (the son) has given a good deal of attention to fossil footmarks and shown great skill in distinguishing and collecting them. Through the liberality of GILBERT SMITH, Esq., the specimen exhibiting the tracks of the fore feet of this animal, has been presented to the Ichnological Cabinet, and a sketch of it is given on Plate XLVI., fig. 5. The specimen which most decidedly indicates a web to the hind foot is from Turner's Falls, (No. $\frac{4}{4}$,) and a sketch of it is given on Plate XLVI., fig. 2, as already remarked.

Nature of the Animal.—From these successive discoveries we may now conclude that this animal was a quadruped, with very unequal feet, and a tail, though of the existence of this appendage I am not certain. I must think that his hind feet were his principal organs of progression, and that he only occasionally brought his fore feet to the ground. I cannot otherwise understand, how we should have before us half-a-dozen long rows of tracks, most of them exhibiting every bone of the foot, and yet only in a single instance have found traces of a fore foot. And in this single case we find that the animal brought both his fore feet to the ground together, not as a quadruped does that uses his fore feet for walking, but for resting, or other purpose. Moreover, the exact alternation of the right and left hind feet in walking, agrees better with the movement of a biped than that of a quadruped, whose tracks show more irregularity in this respect. I think, therefore, that in its progression the Otozoum was a biped, whose tail only seldom reached the ground.

Was the animal, then, a huge marsupial, like the kangaroo? The general character of its feet looks that way. And then, if I have rightly distinguished between the phalanges and the metatarsal and tarsal bones of the feet, we have three phalanges in all the toes except the outer one, which had four. Three is the normal number for mammiferous animals, and it is merely possible, though not probable, that the outer toe had only three, for the impressions are quite distinct. Then the peculiar web of the foot, spread under it like a huge snow shoe, reminds us of a similar arrangement in the Monotremata, the lowest of the mammiferous class.

But on the other hand, what shall we say of the pelleted toes, so characteristic of the batrachian family, and not found, I believe, in any of the mammifers? though in the monotremata the claws have some peculiarities of structure.

Upon the whole, I have decided to place this animal among the Batrachians: but the facts above stated lead to the conclusion that it combined in its nature characteristics now distributed among several different families of animals. I have thought it not improbable that the Otozoum might have used its web-foot, as does the Ornithorynchus, for propelling itself through the water. It would serve, also, an important purpose in buoying up the

animal as it walked over the muddy surface; and that its tracks were usually made above rather than beneath the water, is obvious from the fact that abundant rain-drops occur on the same surface as the tracks.

It is a fact worthy of remembrance, that nearly all the quadrupeds revealed by the fossil footmarks, had fore feet much smaller than the hind ones. The inquiry hence arises, whether, if not all marsupials, they did not all partake largely of the marsupial type. It would not be surprising if future paleontologists should feel justified in placing nearly all those animals in the marsupial class, so as to make the Fauna of sandstone days like that now found in Australia, which, I believe, is nearly all marsupial, inclusive of the monotremata.

GENUS III.—PALAMOPUS, (παλάμη, the palm, or the hand: and πούς, the foot: a foot resembling the hand.)

Hind foot palmated; four-toed; heel stout, bent outwards; toes all directed forward.

Species 1. PALAMOPUS CLARKI.

Palamopus Dananus of Fossil Footmarks of the United States, Plate XI., figs. 1, 2.

[In the Cabinet, No. $\frac{12}{1}$.]

Hind Foot.—Angle between the inner and outer toes, 67°; between the inner and second toe, 25°; between the second and third, 30°; between the third and fourth, 15°. Toes acuminate. Length of the toes, reckoned from the posterior extremity of the heel, commencing with the inner toe, 5.4, 6.5, 8.6, 6 inches. From tip to tip of the toes, in the same order, 2.5, 3.3, 3 inches. Width of the heel near its posterior part, 1.8 inch; do. forward of the inner toe, 2.1 inches. Back part of the heel bent outward. Length of the foot, 8.6 inches; do. of the step, 21 inches. Axis of the foot nearly coincident with the line of direction. Width of the trackway, 5 inches.

Fore Foot.—About 3.5 inches long and 1.5 inch wide, on the only specimen in the Cabinet; but the general outlines only are distinct. It is situated nearly midway between the two tracks of the hind foot.

Outline sketch of the hind foot given on Plate XXIII., fig. 2. A sketch of the whole slab containing this species is given on Plate XLIV., fig. 2.

Locality.—Northampton, back side of Mount Tom, where it was discovered by Professor WILLIAM S. CLARK, whose name, therefore, it seems proper, should be attached to it, even though I exclude another name, which I have always delighted to honor. I have tried in vain to find the layer of rock at the locality from which the slab in the Cabinet was taken, and therefore my description is meagre. But the tracks of the hind feet are too distinct to be mistaken, and too unlike any others to be confounded with them.

Remark.—A sort of general resemblance of the tracks of this species to those of frogs has led me to place it among the Batrachians. Yet the toes are pointed, not pelleted, and there are lizards whose feet do not differ much from this, except that here we have but four toes. In this last respect this track, if it were made by a hind foot, corresponds best to the Croceodilian group, and there perhaps I ought to have placed it.

Genus IV.—MACROPTERNA, (μαχρός, long, and πτέρνα, a heel.)

Heel long; front and hind feet unequal in size; the hind ones four-toed; the front ones five-toed.

Species 1. Macropterna vulgaris.

Ornithoidichnites Rogersi. Transactions of the American Geological Association, Plate 11, fig. 7.

Ornithoidichnites minimus in part. Massachusetts Geological Report, Plate 42, fig. 30, and Plate 45, fig. 41.

Macropterna Rhynchosauroidea. Fossil Footmarks of the United States, Plate XV., fig. 9.

[In the Cabinet, Nos. $\frac{40}{1}$, $\frac{22}{1}$, $\frac{27}{1}$, $\frac{33}{13}$, $\frac{33}{14}$, $\frac{16}{4}$, $\frac{36}{20}$, $\frac{33}{15}$, $\frac{33}{30}$, $\frac{33}{31}$, $\frac{33}{32}$, $\frac{33}{33}$, $\frac{35}{10}$, $\frac{35}{27}$, $\frac{35}{28}$, $\frac{35}{32}$, $\frac{35}{42}$, $\frac{35}{41}$, $\frac{35}{42}$, $\frac{36}{6}$, $\frac{39}{70}$, $\frac{41}{2}$, $\frac{41}{44}$, $\frac{33}{16}$, $\frac{36}{21}$, $\frac{41}{3}$, $\frac{41}{1}$, $\frac{41}{27}$, $\frac{41}{28}$, $\frac{41}{29}$, $\frac{41}{44}$, $\frac{41}{45}$, $\frac{36}{52}$.]

Hind Foot.—Tetradactylous, leptodactylous. Divarication of the lateral toes, 80°; of the inner and second, 30°; of the second and third, 20°; of the third and fourth, 30°. Length of the toes, reckoning outward, 0.2, 0.35, 0.5, 0.5 inch. Length of the heel, 0.6 inch; of the foot, 1.1 inch; of the step, right and left hind foot, 1.8 inch; track to track of the same foot, 4 inches. Axis of the foot in walking turned outward from the median line, from 10° to 20°. Distance of the heel from that line, 0.4 inch. Width of the trackway, 2 inches.

Fore Foot.—Pentedactylous; outer and inner toes opposite. The two inner toes longest, about 0.35 inch; hind toe shortest, 0.15 inch; second do., 0.25 inch; third do., 0.30 inch. Heel visible on the track, about the length of the hind toe. Fore foot placed in walking a little in advance of the hind one, about the same distance from the median line; but the axis turned more outward.

Outline tracks of the hind and fore feet, shown on Plate XXIII., fig. 5. An ambrotype sketch of a fine row, No. $\frac{40}{1}$, shown on Plate XLIX., fig. 6. Fig. 7 of Plate XLVIII. shows a specimen of the same. Plate LII., fig. 3, represents one of the volumes in the stony library, which I presume to belong to this species, although quite possibly it may be another species. On Plate XXXVII., fig. 4, is exhibited a splendid slab procured by the late Dr. John C. Warren, and now owned by his sons. Dr. Warren before his death obtained a painting of this slab of full size, which his son, J. Sullivan Warren, Esq., generously permitted me to copy. Having, however, obtained an accurate outline of the tracks of this species, from other specimens, instead of delineating the imperfect ones on the slab as defective, I have represented a perfect one wherever I found a track at all.

Plate LIX., fig. 5, exhibits an ambrotype sketch of the fore and hind foot, from as perfect a specimen as we have in the Cabinet.

Plate XXXV., fig. 9, is a representation of a very imperfect row of these tracks with the serpentine trace of a tail, furnished me by Roswell Field, Esq., from a specimen

in his collection. To show this tail was the great object in giving the sketch, and though the species may be doubtful, this trace is not. The oscillatory movement of the tail, as stated in another place, was occasioned in my opinion by an unusually rapid rate of progression.

Localities.—Turner's Falls furnishes the best specimens; both below the Falls, where Mr. MARSH found it, and at Lily Pond, where Dr. WARREN's fine slab was obtained by Mr. FIELD. It occurs, also, on the red shale of Wethersfield, and the gray shale of South Hadley, a mile and a half north of the church.

Species 2. MACROPTERNA DIVARICANS.

Sauroidichnites palruatees. Massachusetts Geological Report, Plate XXXIV., fig. 16.

Macropterna divaricans. Fossil Footmarks of the United States, Plate XV., fig. 7.

[In the Cabinet, Nos. $\frac{27}{3}$, $\frac{32}{6}$, $\frac{41}{42}$, $\frac{41}{26}$, $\frac{41}{25}$, $\frac{30}{2}$, $\frac{32}{5}$, $\frac{40}{64}$, $\frac{40}{65}$, $\frac{40}{66}$.]

Hind Foot.—Tetradactylous; divarication of the outer toes, 90°; of the inner and second toe, 20°; of the second and third, 30°; of the third and fourth, 40°. Length of the inner toe, 0.5 inch; of the second, 0.6 inch; of the third, 1 inch; of the fourth, 0.6 inch; of the heel, 1.8 inch; of the foot, 2.8 inches; of the step, 3.3 to 7 inches. Width of the heel, average, 0.45 inch. Distance from tip to tip of the toes, commencing with the inner one, 0.4, 0.65, 0.65 inch. Feet and toes turned outward, sometimes almost at right angles. Distance between the heel and the median line, 0 to 1 inch. Width of the track-way, 3 inches.

Fore Foot.—Five toed; four toes diverging at nearly equal angles, so as to form the radii of a semicircle whose diameter is about 0.6 inch. A fifth inner toe is short and scarcely makes an impression in walking. A very short heel is, also, to be seen sometimes on the track. Position of the fore foot in walking, about half an inch in advance of the hind one. Axis of the foot turned somewhat outward. Not far from the median line.

Remark.—The specimen from which I derive this description of the fore foot is remarkably distinct as to the toes, but the heel is nearly wanting both before and behind. It is, also, less divaricate, as to the hind feet, than the specimen from which the hind foot was described. Perhaps the former, which is No. $\frac{27}{3}$ of the stony volumes, figured on Plate LIII., fig. 4, is a different species from the latter.

Outlines of both feet are given on Plate XXIII., fig. 7.

Localities.—Turner's Falls, below the cataract, where it was discovered by DEXTER MARSH. Also at Lily Pond. The fine specimen of this species formerly in Professor SHEPARD's Cabinet at Amherst, from which my description in Fossil Footmarks of United States was taken, has been sent by him to the British Museum.

Species 3. MACROPTERNA GRACILIPES. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{35}{26}$, $\frac{39}{66}$, $\frac{39}{67}$.]

Hind Foot.—Tetradactylous. Divarication of the lateral toes, 90°; of the inner and second toe, 40°; of the second and third, 25°; of the third and fourth, 25°. Length of

the toes, reckoned outwards, 0.15, 0.25, 0.3, 0.25 inch; of the heel, 0.25 inch; of the foot, 0.5 inch; of the step, from track to track of the same foot, 1.5 to 1.9 inch. Tracks turned but slightly outward from the median line; distance from that line, 0.3 inch. Width of trackway, 1.2 inch.

Fore Foot.—Tetradactylous; form of the foot the same as that of the hind foot, and divarication of the toes about the same. Length of the foot, 0.35 inch; width of do., 0.2 inch. Position of the fore foot, half an inch in advance of the hind one.

Outline of both feet shown on Plate XXIII., fig. 6. A row of the same is shown on Plate XXXIV., fig. 1, copied from No. $\frac{39}{66}$ of the natural size.

Locality.—From Turner's Falls, at Lily Pond.

Remarks.—I think that all the species of this genus have four toes on the hind foot, and five on the fore foot, though the fifth has not yet been discovered on the two last species. But the shortest toe is generally difficult to discover, or rather the trace of it, if any remains, is not easy to find. If I am correct as to the number, the animal seems to have been allied to the crocodilian type.

Genus V.—CHEIROTHEROIDES, (χεἱϱ, the hand, θηϱίον, a wild beast, and εἶδος, an appearance: an animal looking like the Cheirotherium.)

Feet unequal; four toes behind and five before; the three inner toes terminated by pellets; the others blunt.

Species 1. Cheirotheroides pilulatus. (Nov. Sp.)

[In the Cabinet, No. $\frac{34}{31}$.]

Hind Foot.—Tetradactylous; toes all pointing forward. Divarication of the outer toes, 40°; of the inner and second toe, 10°; of the second and third, 15°; of the third and fourth, 15°. Length of the toes in an outward order, 0.4, 0.55, 0.7, 0.7 inch; of the heel, 0.2 inch; of the foot, 0.9 inch; of the step, from track to track of the same foot, 2.5 inches; but often very irregular. Axis of the foot turned outwards from the median line, 20° to 30°; but often irregular in position. Distance between the rows of tracks made by the feet in opposite sides of the body, 1.2 inch. Three inner toes terminated by pellets; or perhaps pelleted claws, for an impression often remains on the rock like a claw, but rounded at its extremity: outer toe having neither claw nor pellet. Outer toe somewhat curved inwards. Width of the trackway, 2.25 inches.

Fore Foot.—Pentedactylous; the three inner toes with pellets; the two outer ones destitute of claws and pellets. Axis of the foot turned outward from the median line almost at right angles. Distance between the right and left foot, 1.8 inch. Length of the toes in an outward order, 0.15, 0.3, 0.35, 0.25, 0.15 inch. Divarication of the first and fifth toe, nearly 180°; the others dividing the included arch about equally. Length of the tracks, 0.45 inch; width of do., 0.45 inch.

An outline sketch of both the hind and fore feet is given on Plate XXIII., fig. 4, from a very perfect specimen belonging to Roswell Field. Fig. 3 of the same Plate

was taken from a specimen in Professor SHEPARD's Cabinet at Amherst. The hind foot of this shows a fifth toe, and had I other specimens to make it quite sure that such a toe exists, (of which I have some doubts,) I should bring this track under the European genus Cheirotherium; no other example of which coming so near to this, have I ever found. Pellets, also, appear on two of the toes of this specimen, and I am not aware that these occur upon the tracks of the Cheirotherium. For the present, therefore, I think it safer to leave this specimen under Cheirotheroides, though from the great perfection of the specimens before me, I cannot believe that a fifth toe will be found in the hind foot of that genus.

Plate XXXVI., fig. 6, is a reduced outline of a beautiful slab of this species (No. $\frac{34}{31}$) in the Cabinet, from which several of the preceding characters were derived. These tracks, as they stand upon the slab, have more the aspect of those of a frog, than any I have ever seen upon stone, yet they have the peculiarity of pointing outward, whereas the common frog of our day turns the toes of his fore foot inwards, as may be seen on Plate LIV., fig. 3. And moreover, the frog has only four toes upon his front foot. Yet the discovery of Professor WYMAN, noticed in another place, of a fossil batrachian with five front toes, shows that this character may not have been the same in sandstone days. I must, therefore, think that the species I have now described comes nearer to the modern frog than any other which I have seen.

Locality.—Lily Pond, where it was brought to light by Mr. FIELD, is the only known locality.

GENUS VI.—SHEPARDIA.

Feet unequal; four to five-toed. Toes behind, connected by a web reaching nearly to their extremities.

Species 1. SHEPARDIA PALMIPES.

[In the Cabinet, No. $\frac{33}{47}$.?]

Hind Foot.—Four, perhaps five-toed: all pointing forward. Divarication of the outer toe, 37°; of the inner and second, 10°; of the second and third, 13°; of the third and fourth, 14°. Length of the toes, reckoning outwards, 0.6, 1.0, 1.2, 0.9 inch. A projection occurs on the outside which is short and blunt, but may be a fifth toe, or the rudiment of a toe. Width of the broad heel, 0.75 inch. Axis of the foot turned somewhat outward from the median line.

Fore Foot.—Pentedactylous; toes turned more outward than those of the hind foot. Divarication of the outer toes, 105°; of the inner and second toe, 30°; of the second and third, 25°; of the third and fourth, 20°; of the fourth and fifth, 30°. Length of the toes, reckoning outwards, 0.4, 0.7, 0.9, 1.0, 0.4 inch. Width from tip to tip of the lateral toe, 0.7 inch. The longest toes a little curved outwards. Position of the track a little in advance of that of the hind foot.

Outline of these tracks shown on Plate XXIV., fig. 2.

Locality.—Turner's Falls, below the cataract, where it was found by DEXTER MARSH.

Remarks.—The specimen from which the above description was taken, is in the Shepard Cabinet at Amherst, and I think we have only a doubtful one in the Ichnological Cabinet. As only one hind and one fore foot are shown on the slab, the description is imperfect. The web is its most striking peculiarity; but it has other distinctive marks, as a comparison of its outline with that of others, will show. Professor Emmons has figured a specimen, in his work on Geology, from the State Collection at Albany, purchased of the estate of Mr. Marsh, which appears to me to belong to the same genus. But I have not access to his work at this time.

I have dedicated this genus to my friend, Professor Charles U. Shepard, LL. D., as a testimony of my respect for his scientific character and labors, and especially for his extraordinary industry and success in collecting one of the most splendid cabinets of simple minerals, meteorites, and organic remains, in our country.

Genus VII.—LAGUNCULAPES, (*Laguncula*, a small flask, and *Pes*, a foot.)

Feet alternating when walking; toes, four, swelling towards the extremity, so as to resemble small flasks.

Species 1. Lagunculapes latus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{33}{29}$, $\frac{33}{29}$ (bis).]

Feet alike; tracks on opposite sides of the animal more or less alternating. Toes, four, the outer ones spreading at least 180°. Angle between the inner and second toes, 50°; between the second and third, 70°; between the third and fourth, 65°. Length of the toes, reckoning in an outward order, 0.5, 0.55, 0.8, 0.6 inch. From tip to tip of the toes in the same order, 0.5, 0.9, 0.75 inch. Length of the foot, 0.85 inch; breadth of do. 1.25 inch. Toes swelling out towards their extremities, and having a rounded termination, without claws, or pellets, so as to resemble small flasks, whose greatest diameter is 0.2 inch. Length of the step, from track to track on the same side, 4.1 to 5.1 inches; reckoning on the alternate tracks, 3 inches. Tracks turned somewhat outward from the median line, and distant from it, 1.25 inch. Width of trackway, 3 inches.

Outline of the track of this species shown on Plate XXIV., fig. 1. An ambrotype sketch of a slab of this species is shown on Plate XLV., fig. 4.

Locality.—Turner's Falls; found by Mr. Field, in a gray micaceous sandstone resembling mica slate.

Nature of the Animal.—It might have been a biped; but the number of toes and the width of the body make it improbable that it was a bird. The shape and number of toes agree better with lizards or batrachians than with birds, as does also the absence of claws and pellets. I put it, therefore, among the Batrachians; presuming rather, that a fore foot may be discovered. But if not, the animal might have resembled the banded Proteus, whose tracks are shown on Plate VI., fig. 7. The Proteus, like the Lagunculapes, had four toes on its feet. Yet the flask-shaped aspect of the toes agrees better with

certain lizards, such as the Anolis. (See *Fossil Footmarks of the United States*, Plate XX., fig. 7.) Here we have that blending of the characters of different existing classes, which so often meets us in our ichnological researches. In giving the animal a place among the Batrachians, I have given the precedence as evidence to the number of toes over their form. So distinct and well pronounced are the toes, that I can hardly believe a larger number will be discovered.

GENUS VIII.—SELENICHNUS, (σελήνη, the moon, and ἴχνος, a track; the moon-shaped track.)

Animal caudate, with two (possibly four) feet; when walking, the feet make an impression with the tail, which resembles the rachis of a plant with alternate falcate branches. Body of the animal very narrow; feet plantigrade.

Species 1. SELENICHNUS FALCATUS. (Nov. Sp.)

[In the Cabinet, No. $\frac{33}{6}$.]

Middle toe much the longest, and curved inwards towards the median line. Outer toe the next shortest, and curved inward. Inner toe rarely distinct from the others on the track. Length of the toes, reckoning from the extremity of the heel and in an outward order, 1.4, 2.8, 2.2 inches. Length of the step, measuring from track to track of the right and left feet, 3.5 inches; measured from track to track of the same foot, 6.5 inches. Width of the foot, 0.7 inch. Versed sine of curvature in the middle toe, 0.25 inch; toes rounded at the end. Trace of the tail continuous and nearly straight; width, 0.2 inch. Heel of the foot in walking brought usually upon the median line; the axis of the foot turned outward from 10° to 20°, so as to give the whole line of tracks strikingly the appearance of the stem of a plant with alternate branches or leaves. Width of the trackway, 2.5 inches.

An outline sketch of a track of this species is shown on Plate XXIII., fig. 8. A reduced outline of a row of fifteen of these tracks is given on Plate LX., fig. 8.

Locality.—Turner's Falls at the Ferry, where it was obtained in the fall of 1857, by ROSWELL FIELD, Esq., and the slab containing the tracks belongs to him.

Remarks on the Nature of the Animal.—One familiar with tracks cannot look at Mr. FIELD's specimen without perceiving that it is different from any thing hitherto discovered. So far as yet appears, it was a biped; and so distinct and deep are the tracks, (though the minuter parts of the foot are not well exhibited, but are blended together, as if the mud were too yielding,) that it seems difficult to suppose we should not find traces of the fore feet, had they existed. Yet I presume the animal had fore feet, probably quite small; for it is difficult to conceive how a caudate animal with so narrow a body could have walked so nearly on a line. Did not the tracks alternate so regularly, we might consider its structure to be analogous to that of the Proteus. Such an animal, however, could not walk upon a line, or rather its feet would be farther spread apart. The long middle toe corresponds well with that of some lizards; but the number of toes (a point not well settled) brings it rather among the Batrachians, and I have placed it there, among the Salamanders.

Species 2. Selenichnus breviusculus. (Nov. Sp.)

(The description of the preceding species will answer for this in its leading characters; I add only a few that may be distinctive.)

Angle between the axis of the foot and the median line, 0° to 10°; length of the foot, 1.8 inch; width of the same, 0.5 inch; width of the tail trace, 0.1 inch. Length of the step, of the alternate tracks, 1.6 to 2.3 inches; of the same foot, 3 to 4 inches. Width of the trackway, 1.5 inch.

An outline sketch of the track of this species is given on Plate XXIII., fig. 9. A row of seventeen tracks is shown on Plate LX., fig. 7.

Locality.—Turner's Falls at the Ferry, found in connection with the preceding species, and may perhaps be the young of that species. But the disparity is great, and I think a difference of size is not the only one. But the specimen of this last species is less distinct as to the parts of the foot than that of the other.

I strongly suspect, from a hasty examination, that the sketch on Plate XXV., fig. 9, referred to Macropterna vulgaris, is a Selenichnus,—the S. breviusculus. If so, we have in that specimen fore feet. But as I only examined this and all the specimens in Mr. Field's Cabinet of the Selenichnus for a short time, I feel in doubt. One wants specimens of this sort near him for some time, that he may re-examine them again and again. Nothing but a want of means prevents me from securing for the Appleton Cabinet at least one specimen of all the species described in this Report, that others may correct my mistakes and misapprehensions. But I perceive that I shall be obliged to describe a few species from specimens possessed by others.

INCERTÆ SEDIS.

As already stated, this phrase implies that the animals described under it have no characters by which we can fix their place among living tribes. The following anomalous genera I place here till more light is thrown upon their relations.

Genus IX.—HOPLICHNUS, (ὁπλή, a hoof, and ἴχνος, a track; the hoof track.)

Quadrupedal; hind feet somewhat the largest; track hoof-shaped.

Species 1. Hoplichnus equus. (Nov. Sp.)

Tracks described and figured by Dr. Cotta from Polzig in Saxony, in 1839, without a name. *American Journal of Science*, Vol. 38, p. 255.

Chelichnus gigas, of Sir William Jardine; *Ichnology of Anandale*, Plate I.

Remarks.—I have not probably any specimen of the track of this species; but No. $\frac{29}{3}$ has on it a remarkable cavity, three inches deep, and fourteen inches in its longest diameter, which I have reason to suppose was made by the posterior part of the body of the animal. For at the Middlesex Quarry at Portland, Connecticut, I saw (November, 1857) a huge slab, weighing I doubt not at least two tons, and which could not be reduced, having

on its surface this same ovoidal depression between two rows of tracks of Hoplichnus. A similar specimen, too heavy to be put into a Cabinet, I shall describe as I proceed to give the character of the species.

Description.—Imprint of the foot almost exactly like that of a horse with shoes, viz.: a ring-like depression about the size of a small horse shoe, with a somewhat oval elevation within, showing that the under side of the foot was hollow. No claws have made an impression. But a sort of trail runs backward frequently from the two posterior extremities of the track, extending several inches, and they converge so as to unite and terminate in a point. I formerly thought this might proceed from a slight current of water passing by the raised sole or pad of the foot: but I find it on almost every track, and, therefore, presume that the foot struck the ground before it had reached the spot where it was planted. Hind foot somewhat the smallest; the two feet placed near together, succeeded by an interval of 40 to 48 inches, which I consider the length of the step. Distance between the two rows of tracks, 24 inches. On the median line is a depression seven inches in diameter, not a little resembling a huge track, and showing a similar trail behind it, which extends four or five feet. This I must regard as a caudal appendage, and the cavity as made by the posterior extremity of the body, or perhaps by the caudal appendage. It has already been stated that a similar and still deeper depression occurs on No. $\frac{29}{3}$, from the Portland quarries, which is repeated at the distance of 27 inches, and on a slab which I left at the quarry, a depression of this sort was connected with the tracks of this species, as at Deerfield on the slab figured on Plate XXIV., fig. 5. Width of the trackway, 27 inches.

The outline of the fore and hind feet of this species are shown on Plate XXIV., figs. 3 and 4; though I am not sure which is the fore and which the hind foot. As just intimated, fig. 5 was copied, without attempting entire accuracy, from a slab of huge dimensions lying in the portico of the kitchen of Mrs. Mary Nims, of Deerfield, which is too large and heavy I fear to find a place in any Cabinet.

Localities.—The slab just named was brought from the Horse Race locality in Gill. The Portland quarries afford the same species I think; but there too, the slab containing the best specimen, was too heavy to think of ever removing it to a cabinet. The specimen at Deerfield, however, will probably retain its place for generations, and I trust that others may be brought to light at Portland.

Remarks.—I can hardly doubt that this genus is the same as the Chelichnus of Sir William Jardine, and probably this species may be the same as his C. gigas. The specimen which he showed me at Edinburgh in 1850, I recognized at once as my Hoplichnus, though it was of a smaller species than the C. gigas. But in his Ichnology of Anandale, he has described the Testudo Duncani of Owen as a species of Chelichnus, although it has distinct claws. I saw the fine specimen of this species in the Ashmolean Museum at Oxford, which is figured by Dr. Buckland in his Bridgewater Treatise, and it seemed to me to be quite a different genus from my Hoplichnus, which never shows any toes or claws. Probably they existed, and the suggestion of Sir William that they were prevented from leaving an impression by a membrane beneath the bones which reached beyond the claws,

like that of the Ornithorhynchus, is certainly quite probable. But the absence of this membrane, so that the toes or claws would leave an imprint, I should consider a sufficient difference to constitute another genus, as it certainly would be among living animals. I shall not, therefore, regard his Chelichnus Duncani as a synonym of my next species.

Species 2. Hoplichnus poledrus. (Nov. Sp.)

Hoplichnus quadrupedans. Fossil Footmarks of the United States, Plate XVI., figs. 7 and 8.

[In the Cabinet, Nos. $\frac{36}{1}$, $\frac{36}{2}$, $\frac{36}{3}$.]

Ring-like depression varying in its shortest diameter, from 1.76 to 2.1 inches; in its longest diameter it varies from 1.75 to 2.5 inches. Width of the ring from 0.25 to 0.6 inch. Width of the hollow in the bottom of the foot, 0.9 inch. Two faint shallow furrows extending backward from both ends of the semicircular ring of the tracks, and uniting at a small angle into one. Fore and hind foot placed near together when walking; succeeded by an interval of nearly a foot, which is the length of the step. Distance between the two rows of tracks, about five inches. Tracks of the fore and hind foot unequal in size; the fore foot probably the largest, but I am not certain which is the fore foot. Width of the trackway, 7 inches.

An outline of the tracks of this species is shown on Plate XXIV., figs. 6 and 7. An ambrotype sketch of specimen No. $\frac{36}{1}$ is given on Plate XLVIII., fig. 9.

Locality.—I have never seen this species any where else save at Turner's Falls at the Ferry, where it was got out by Dexter Marsh.

Remarks. — This species differs from the H. equus but little except in size, though it has never shown on any specimen of tracks a caudal or abdominal impression like the H. equus; nor is it as wide, in proportion to its size, between the rows of tracks. The larger species remind one of a full grown horse's tracks; the small one of a colt, and hence the specific names, — the first meaning a horse; the other a colt.

In one or two of the tracks of the H. poledrus, we find several depressed spots in the ring that may indicate toes, but no claws. But whether the toes are shown or not, I cannot doubt their existence; for otherwise we must suppose the animal to have been one with a solid hoof. This would be an extremely improbable, though I will not say impossible hypothesis. But admitting it to have been a quadruped with toes, concealed by a wide web, what could have been its nature? The Scottish tracks allied to those of the Hoplichnus, Sir William Jardine seems inclined to refer as the generic name Chelichnus, implying Chelonians or Tortoises. But one character in our tracks, (which is not the same in the Scottish tracks, unless in the C. gigas to some extent,) I mean the great length of the animal's stride, is different from what any living tortoise could form, and it leads us rather to the mammiferous class, as most likely to leave such lines of tracks. But in either case, what shall we do with the caudal or abdominal impression? Then, if the animal had a web beneath, and extending beyond its toes, our thoughts recur to the Monotremata, where the duck-billed Platypus, or Ornithorynchus, has such a foot. But the Hoplichnus

must have had legs much longer proportionally. At present I think it better to leave these animals among those of the *incertæ sedis*—whose place is not settled.

M. COTTA, in his account of the tracks in Saxony, evidently similar to the above, supposes the foot to have been didactylous, and consequently that the animal moved in a direction opposite to that we have supposed. I am not aware of any analogous feet among living animals; but there are some things on our tracks that would favor such a supposition. I refer particularly to that sort of trail that proceeds from the tracks and the middle impression, which, on such a view, might be explained by supposing that the feet and tail dragged for a time after the animal lifted them up. I think too that the smallest foot is usually behind the other, if the animal moved in the direction I had supposed; whereas in most cases the smallest foot is in advance of, or at least as much advanced, as the large one; so that I think this suggestion of M. COTTA deserves attention, yet in Saxony he found no rows of tracks, but only isolated ones.

GENUS X.—SALTATOR, (the leaper.)

Animals small; moving generally by leaps.

Species 1. SALTATOR BIPEDATUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{37}$, $\frac{36}{43}$.]

Didactylous. Right hand track, 0.3 inch long; left hand, 0.25, or not making so full an impression. Toes 0.1 inch wide, rounded at both ends; slightly divaricate; 0.2 inch apart at the heel; animal moving in a right line; length of the leap, 1.25 inch. Width of the trackway, 0.3 inch.

An outline of the only specimen of this species in the Cabinet, showing a row of three leaps, is given of the natural size, on Plate XXIV., fig. 8. An ambrotype sketch of the whole slab is shown on Plate LI., fig. 7.

Locality.—Turner's Falls, I think on Mr. FIELD's farm.

Nature of the Animal, &c.—Though the tracks of this species are distinct, and on a surface that would almost certainly retain the slightest markings, yet of the nature of the animal I can scarcely offer a conjecture. The tracks have the aspect of those made by a mouse, or small squirrel, leaping along in fresh snow; and I can conceive that the leaps of a jerboa (deer mouse) would show a still closer resemblance. But whether the Saltator had more than two feet, or whether the two impressions were not rather made by the toes of one foot, rather than feet, I am unable to decide. Their almost exact resemblance, as to relative position, favors the idea of toes rather than feet; but in that case we must imagine the animal moving along upon one foot, which is improbable; and then, a small animal moving by leaps preserves its hind feet almost exactly in the same position. I have, therefore, made the specific name conform to the idea of feet rather than of toes. But whether the animal was a small quadruped, or perchance an insect, I have no settled opinion.

Species 2. Saltator caudatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{3}$, $\frac{9}{9}$.]

Impressions of the animal's feet upon the mud, rounded, or somewhat elliptical dents, not more than the thirtieth, or the twentieth of an inch, in diameter. Where the animal rested, we find five of these, and sometimes what seems to have been a tail behind, 0.4 inch long. As the animal advanced, only three, and sometimes only two of his feet made an impression, the dents being arranged in the form of a triangle, sometimes oblique angled, sometimes rectangular, and sometimes equilateral. Length of the leap, 0.8 to 1.1 inch. Width of the trackway, 0.3 inch.

Plate XXIV., fig. 9, is a copy of the natural size of the tracks of one of the best specimens of this species. Fig. 10 shows another, on No. $\frac{1}{3}$, which might more properly be regarded as a variety of S. bipedatus, or more probably, a third species; for it is too small for the S. bipedatus, and the tracks are not arranged like those of S. caudatus, although it seems to have had a tail.

Locality.—Turner's Falls, at Lily Pond, on the same slabs which show the tracks of Gigantitherium caudatum and minus.

What was the Nature of this Animal?—I feel entirely incompetent to throw any light on this question. I dare not say even how many feet the animal had; for I find five impressions where the animal seems to have rested, and hence it may have been an insect. I have even fancied that the common black cricket, so frequent in the autumn, might leave an analogous set of impressions at its successive leaps and occasional pauses. But its leap would be five times greater than that of the saltator caudatus; if, indeed, the latter leaped at all. But I will not multiply useless words. And yet the characters of this species seem so trenchant and peculiar, that I cannot doubt its true nature will be hereafter made out satisfactorily. I think the difficulty lies in our ignorance of the manner in which the smaller animals move over the surface.

GROUP VII.—CHELONIANS OR TORTOISES.

Remarks.—I can hardly doubt that tortoises must have been common during the sandstone era of the Connecticut Valley, and yet this is one of the most unsatisfactory of all the Groups I have attempted to describe. For it is very difficult to distinguish between the tracks of Chelonians and those of Lizards and Salamanders. I have referred a few species to Chelonians, first on the ground that their legs turned a good deal outward in walking; secondly, because they had wide bodies; and thirdly, because they sometimes left traces of the dragging of their feet through the mud so as almost to obliterate the tracks, and also traces of a tail and a shell or carapace.

Genus I.—ANCYROPUS, (ἄγκυρα, an anchor, and πούς, a foot; the anchor-like foot.)

Fore feet much the most slender. Toes very much curved outward from the line of direction. Tracks in parallel rows, wide apart.

Species 1. ANCYROPUS HETEROCLITUS.

Sauroidichnites heteroclitus and Jacksoni. Massachusetts Geological Report, Plate 30, figs. 2 and 3.

Ancyropus heteroclitus of Fossil Footmarks of the United States, Plate XV., figs. 3 and 4.

[In the Cabinet, Nos. $\frac{27}{7}$, $\frac{27}{12}$, $\frac{32}{12}$, $\frac{32}{49}$, $\frac{34}{32}$, $\frac{34}{33}$, $\frac{34}{11}$, $\frac{41}{50}$, $\frac{16}{3}$, $\frac{16}{2}$.]

Hind Foot.—Four (probably five) toes; one pointing inward from near the extremity of the heel, almost at right angles to the axis of the foot, the rest pointing forward and very much curved outward. Length of the hind toe, which is straight, beyond the heel, 0.5 inch; difficult to determine the length of the others, on account of their curvature and coalescence. Width of the heel, 0.7 inch. Length of the foot, 2 inches. Toes slender and lithy, with acute terminations. Versed sine of the outward curvature of the toes, from 0.4 to 0.7 inch, which is larger in proportion to their length, than in any other track in the Cabinet. Length of the step from track to track of the same foot, 4.5 to 5.5 inches. Distance between the rows of tracks, 6 to 7 inches. Axis of the tracks nearly parallel to the median line. Behind the heel a rounded process has made an impression on the mud, whose nature (unless it be a process of the tarsal bones) I am unable to conjecture. Some peculiarity of structure must also have existed on the outer posterior extremity of the heel, which caused the mud to form a rounded eminence above the general surface, probably by suction. Width of the trackway, 6.5 inches.

Fore Foot.—Toes four, perhaps five; one of them proceeding from the end of the heel inward at right angles to the heel, 0.6 inch in length; the others directed forward and curved outward almost into a semicircle; the versed sine being fully equal to that on the hind foot. Width of the heel, 0.3 inch. Curved inward strongly. Behind the part of the heel that impressed the mud, the same peculiarity exists in the leg as in the hind foot, causing an elongated elevation beyond the heel. Length of the foot, exclusive of this elevation, 2 inches. Position of the fore foot in walking, almost directly in front of the hind one, and on the same line.

An outline of the hind foot of this animal is given of the natural size on Plate XXV., fig. 3; and of the fore foot, on fig. 4. An ambrotype sketch of the hind foot is given on Plate LIII., fig. 1; and of the fore foot on fig. 2. These specimens, however, Nos. $\frac{27}{12}$ and $\frac{27}{7}$, are stony volumes, the first with three, and the latter with four leaves. The sketches can of course exhibit only one opening of the leaves.

Locality.—On the gray shale of Wethersfield Cove.

Affinities.—The great width of the body, the shortness of the steps, and the outward curvature of the toes, seem to correspond better to Chelonians than to lizards, or Salamanders. Yet the slenderness and lithiness of the toes is remarkable, and whether it has any parallel in living tortoises, I am ignorant. I think it will turn out, that the number of toes, especially behind, is five, which in fact I think I can discern upon some specimens, though those from which the drawings were taken, do not show them. The

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mud on which the animal trod must have been very fine and plastic, and probably it sunk deep and the sides more or less collapsed. The hind toe on the fore foot shows itself only on an upper layer, above where the rest of the track is most distinct; a fact which I have noticed under Apatichnus.

GENUS II.—CHELONOIDES, (χελώνη, a tortoise, and εἶδος, appearance; resembling a tortoise.)

Front foot the largest; pentedactylous; hind foot tridactylous; (tetradactylous?) animal's body wide.

Species 1. CHELONOIDES INCEDENS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{9}{10}$, $\frac{6}{1}$.]

Distance between the rows of tracks, 5.5 inches. Length of the fore foot and heel, 1.7 inch; of the hind foot, (if I am not mistaken,) 1.1 inch. Fore foot pentedactylous; length of the toes, reckoning outwardly, 0.4, 0.7, 0.9, 0.8, 0.8 inch; of the heel, 1.1 inch. Divarication of the outer front toes, (2d and 5th,) 100°. Inner toe set back upon the heel. Axis of the foot nearly parallel to the median line. Length of the step from track to track of the same foot, 14 inches. Fore foot certainly three and probably four, perhaps five-toed. Three toes pointing forward. Length of the foot, 1.1 inch; width, the same, do.; of the fore foot, 1.3 inch. Toes trailing from track to track. Hind and fore feet in walking near together, and almost equidistant from the median line. Width of the trackway, 6.5 inches.

An outline of the tracks of this species is shown on Plate XXXI., fig. 3.

Locality.—Turner's Falls, Lily Pond.

Remarks.—We have two specimens of this species in the Cabinet, which I have tried in vain to refer to any others described in this Report. They are not as good as I could wish; yet they show the general characters of the tracks and the mode of progression. I find the smallest track behind the other, and hence have spoken of it as made by the hind foot; which is contrary to the general analogy of these footmarks, and yet by no means without precedent both among living and fossil species. The unusual width of the body has led me to refer this species to Chelonians; and yet the length of the step is great for such animals. But the legs were long if it were a chelonian, since there is no evidence that either tail or carapace dragged upon the ground. The length and regularity of the step are referred to in the specific name.

GENUS III.—HELCURA, (ἕλκω, to drag, and οὐρά, a tail; the tail dragger.)

Quadrupedal; tail and toes often dragging upon the ground.

Species 1. HELCURA CAUDATA.

Helcura litoralis of Fossil Footmarks of the United States, Plate XV., fig. 1.

[In the Cabinet, Nos. $\frac{26}{10}$, $\frac{19}{9}$, $\frac{20}{7}$.]

Two rows of indistinct tracks; the feet about 2 inches long, but the toes cannot be counted. Toes making an almost continuous trail from track to track. Distance of the

toe trails, 2.5 to 3 inches. Two tracks near together and then a wider interval. Length of the step not less than 6 inches from track to track of the same foot. Trace of a tail between the rows of tracks. General course of the trail strait. Width of the trackway, 5 inches.

I have not attempted to give an outline sketch of this and the two following species of the natural size; but only a reduced outline on Plate XXXVII., fig. 3, and an ambrotype sketch of one of the slabs containing this species on Plate XL., fig. 1.

Localities.—I purchased the slab exhibited on Plate XL., fig. 1, of DEXTER MARSH, who procured it at Turner's Falls, at the Ferry. The same species has since been found by Mr. FIELD, at Lily Pond.

Species 2. HELCURA SURGENS. (Nov. Sp.)

[In the Cabinet, No. $\frac{19}{8}$.]

The description of the last species applies to this, except that this shows no trace of a tail, and the traces of the feet are from 4.5 to 6 inches apart, showing a greater width to the body. From the absence of the tail track, I infer that the animal carried its body higher than the H. caudata, as the specific name, *surgens*, or *lifting up*, implies. The trail of one of the feet shows three toes distinctly. Width of the trackway, 5 to 6 inches.

A reduced outline of this track is shown on Plate XXXVI., fig. 10, taken from No. $\frac{19}{8}$.

Locality.—Turner's Falls, at Lily Pond.

Remark.—I regard the much greater width of the body in this species, to say nothing of the absence of a tail trace, to be sufficient to distinguish it from the species that precedes as well as that which follows.

Species 3. HELCURA ANGUINEA. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{40}{8}$, $\frac{40}{15}$, $\frac{19}{9}$.]

Width between the trails of the feet, 1.5 to 2 inches. Trace of a carapace (?) sometimes seen. (No. $\frac{19}{9}$.) Length of the step from track to track of the same foot, 5 to 6 inches. (?) Trails much finer than in H. caudata, sometimes serpentine, and hence the specific name. Width of the trackway, 3 inches.

An outline trail of this species much reduced, is shown on Plate XXXVI., fig. 9, from No. $\frac{40}{8}$.

Localities.—Turner's Falls, below the Falls, on soft gray shale, where it was found by DEXTER MARSH; also at Lily Pond, where it was found by ROSWELL FIELD.

Remark.—The trail of this species is rather narrower and much more slender than that of H. caudata, which characters, to say nothing of the absence of a tail trace, make it probable that the two species are distinct.

Affinities of the Genus.—The trails of the toes are the chief characteristics of this genus, since the tracks are too obscure to be described, save in general terms. These trails, especially when, as in H. caudata, the tail dragged, correspond better I fancy with Chelo-

nians than with any other reptiles. At least, I have seen tracks of living land tortoises which made an impression upon me similar to those of this genus, though, unfortunately, I failed to secure a drawing of them. I place these species, therefore, among tortoises, with a rather strong conviction, but not with entire confidence, that such was their nature.

GENUS. IV.—EXOCAMPE, (ἔξω, outward, and καμπή, a curve; bending outward.)

Fore and hind feet unequal in size. Most of the toes curved and turned outward very much from the line of direction.

Species 1. EXOCAMPE ARCTA. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{35}{24}$, $\frac{41}{20}$, $\frac{35}{5}$, $\frac{31}{1}$.]

Hind Foot.—Tetradactylous; toes all pointing forward, and all, except the inner one, turned and curved outward from the line of direction. Inner toe strait, second one but slightly curved, the third bent most of all, and the fourth nearly as much. Versed sine of the curvature in the third toe, 0.25 inch. Length of the inner toe, 0.8 inch; of the second, 1.1 inch; of the third, 1.3 inch; of the fourth, 1.3 inch. Divarication of the outer toes, 110°. Length of the tapering heel, 0.8 inch; of the foot, 1.9 inch; of the step, from track to track of the same foot, 8.5 inches; but sometimes probably not more than 2.5 inches. Distance of the track from the median line, rarely over an inch, often much less. Foot generally digitigrade. Width of the trackway, 3 inches.

Fore Foot.—Pentedactylous; toes turned outward much more than those of the hind foot, but curved less. Length of the toes, reckoning outward, 0.35, 0.9, 0.1, 1, 0.5 inch. Divarication of the lateral toes, 110°. Foot placed in walking a little in advance of the hind foot, and considerably farther from the median line.

An outline sketch of the most perfect tracks of this species in the Cabinet, (No. $\frac{35}{24}$) is given on Plate XXV., figs. 5 and 6. The best row of the tracks of the hind feet only, is shown on the ambrotype sketch, Plate XLIX., fig. 5, one of which of the natural size is shown on Plate XXV., fig. 10. This is a digitigrade impression, and has no trace of a fore foot, and may possibly not be the same as No. $\frac{35}{24}$, from which I derive the characters of the species.

Remark. — By mistake the outlines of this genus on Plate XXV., figs. 5, 6, and 11, are named Hectocampe instead of Exocampe, on many impressions.

Localities. — Turner's Falls, below the Falls, and at Lily Pond.

Affinities of the Genus. — The outward curvature of the toes seems to me to agree best with a chelonian; but the narrowness of the body looks more like a lizard. The shortness of the heel, and the rounded rather than elongated form of the foot are chelonian characters. I am not without fears that I may have mistaken the hind and fore feet from the defects of my specimens, or that I have confounded two species. No. $\frac{41}{20}$, although it shows a beautiful row of what I call hind feet, has no fore feet, while the specimen that has both, is so small as to have on it but three tracks. In such cases I shall expect that future discoveries will require modifications of my opinions. But I do the best

I can with the data in my power, and leave the rest to those who come after me. I shall expect that they will oftener have occasion to modify the Groups than the genera and species.

Species 2. Exocampe ornata. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{41}{39}$, $\frac{26}{9}$, $\frac{6}{1}$, $\frac{41}{12}$, $\frac{41}{50}$, $\frac{41}{41}$, $\frac{22}{1}$, $\frac{33}{40}$, $\frac{34}{23}$, $\frac{36}{43}$, $\frac{39}{69}$, $\frac{39}{71}$.]

Hind Foot. — Digitigrade; tetradactylous; toes curved outward gracefully; length, reckoning outward, 0.22, 0.3, 0.4, 0.32 inch, so far as they impressed the mud in walking. Divarication of the outer toes, 100° to 130°. Divergence of the axis of the foot from the median line outward, 15° to 25°. Distance of the heel from the median line, 0.3 to 0.7 inch. Length of the step from track to track of the same foot, 4 inches. Width of the toes before and behind, less than the tenth of an inch. Toes acuminate with claws, — at least on a part of them. Width of the trackway, 1 inch.

Fore Foot. — Digitigrade, but less so than the hind foot; pentedactylous; one short hind toe, and the four front ones about equally distributed through an arch of 130°, and about of equal length, say 0.3 inch. Axis of the foot turned outward from 40° to 70°; toes also, somewhat curved outward. Fore foot situated, say a quarter of an inch in advance, and a little outside of the hind foot in walking.

An outline sketch of this species is given on Plate XXV., fig. 11, copied from a fine specimen, No. $\frac{41}{39}$. An ambrotype sketch of this slab is given on Plate XLVIII., fig. 6. Fig. 1 of the same Plate shows a slab with a row of the hind foot only, which is a not unusual occurrence.

Locality. — On the soft gray shale below the cataract at Turner's Falls, where it was obtained by Dexter Marsh.

Remarks. — This species may not differ very materially from the last, except that it is less than half the size, and obviously of a more delicate and slender form, if we may judge from the tracks. So different is its aspect from that of H. arcta, that for a time I referred it to Macropterna vulgaris. But every thing is made more satisfactory to regard it as a second species of Exocampe. There are several good specimens in the Cabinet, besides the finest, No. $\frac{41}{39}$; but they are mostly wanting in the fore foot.

The remarks under the first species were penned before I discovered the H. ornata; but it is hardly necessary to change them as the affinities of this species seem to correspond to those suggested under H. arcta.

Genus V. — AMBLYPUS, (ἀμβλύς, blunt, and πούς, foot; the blunt foot.)

Foot rounded, toes short and blunt, curved outward.

Species 1. Amblypus dextratus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{34}{17}$, $\frac{34}{18}$, $\frac{34}{26}$, $\frac{34}{27}$.]

Only the right feet (whether the front or hind feet cannot be determined) have left tracks upon the rock, with a single exception; and hence the specific name, *dextratus*,

meaning *lying to the right.* Impression quite deep; toes indistinct, not more than three visible, all curved inward towards the line of direction, while the axis of the foot turns outward. Foot strongly plantigrade; length one inch, half of which is heel. Length of the step, 4 to 4.5 inches. Only a single rather superficial impression of a track by the left feet is visible on any of the specimens. Breadth between the two rows of tracks, 1.8 inch. Probably a fourth toe, short and pointing backward from the inner side of the heel, exists. Width of the trackway, 4 inches.

An outline sketch of this track of the natural size, is given on Plate XXV., fig. 7. An ambrotype sketch of one of the specimens in the Cabinet is given on Plate XLVIII., fig. 5.

Remarks. — I am not quite sure whether it is the right or left row of tracks that is shown on the specimens. If the left, the specific name should be *scævus*, as I first had it, instead of *dextratus*. One left hand track is, indeed, tolerably distinct; but there is another equally so perhaps on the right side on another specimen. It is unaccountable that while the right hand row is unusually deep, those on the left hand should be so generally wanting. Yet the outward direction of the axis of the foot and the inward curvature of the toes are uniform, and forbid the supposition that there was but a single row. But I can hardly believe that if another set of feet existed, as fore or hind feet, they should not have left some trace. And I am rather inclined to regard this animal as having legs arranged as in the Proteus; which did not leave tracks in pairs as other quadrupeds, but in succession and sometimes alternation, like birds. See Plate VI., fig. 7. This might be done by a tortoise, and though not decided in opinion as to the nature of this animal, I have placed it among the Chelonians, chiefly from the form of the foot, which approximates to that of some tortoises.

GROUP VIII. — FISHES.

Remarks. — It was not till near the time when this manuscript was ready to pass into the printer's hands, that I was led to introduce Fishes as one of the Groups of animals that made the fossil tracks. I had placed the genus Ptilichnus among those whose place I could not determine, (incertæ sedis,) not without a suspicion, however, as the name implies, that fishes might have produced the impressions. But the accidental discovery among my specimens of a new species, (the P. hydrodromus, most obviously made by an animal swimming just above a surface of ripple marks,) and some facts mentioned to me by Professor J. Wyman respecting the Siluroid fishes of Surinam, have led me to introduce this group, in the belief that it has as good ground to rest upon as some of the other Groups. I do not, indeed, feel entire confidence that I have reached the truth. But a little light where one has to grope so much in the dark, is exhilarating.

Genus I. — PTILICHNUS, (πτίλον, a fin or feather, and ἴχνος, a track; the fin track.)

Organs of locomotion making an impression on the mud, like the flapping of a fishes fin, or a bird's wing, each successive flap being more or less in advance of the other. Dents, also, are sometimes seen along the margin of the fin-like impression, as if a longer and pointed fin ray had made them.

Species 1. Ptilichnus anomalus. (Nov. Sp.)

(Characters additional to those of the genus.)

[In the Cabinet, Nos. $\frac{20}{9}$, $\frac{36}{8}$, $\frac{36}{9}$, $\frac{36}{12}$, $\frac{36}{13}$, $\frac{36}{51}$.]

Fin-like impressions sometimes arranged in two rows, (Plate XXV., fig. 1,) 2.5 inches apart, as if made by organs on both sides of the animal; generally, however, they show only a single row. The line of dents, or circular impressions, along the border (outside?) are distant from it sometimes an inch, and sometimes in contact with it. Diameter from 0.1 to 0.2 inch, seeming as if made by a blunt cylindrical stick, perhaps a fin, of that shape. The broad fin-like impression has an irregular border, and the surface shows nearly parallel ribs, rarely more than 5 or 6, not more than 0.25 inch apart, crossed obliquely by shorter ribs, or rather each principal depression seems to be made up of short minor depressions, placed somewhat oblique to the general direction of the ribs. These rows of depressions are sometimes 4 or 5 inches long, when a new set succeeds; the two, however, often overlapping, and frequently changing a little to the right or left. Width of the trackway, 5.3 inches.

An outline of the tracks of this species of the natural size is shown on Plate XXV., fig. 1, where two fin-like impressions are shown with a space between them, copied from No. $\frac{36}{13}$. Fig. 2 shows a specimen with a row of the dots along the margin.

Locality.—Turner's Falls, at Lily Pond, obtained by Mr. Field.

Nature of the Animal.—At first I was inclined to refer the impressions under consideration to a vegetable; and afterwards to the action of water. But neither of these suppositions were satisfactory. I then regarded it as of animal origin, but could get no clue to the nature of the animal. But I venture now to suggest that it may have been made by some sort of fish, either beneath the water, or on the land, where it is well known some species of fish will work their way with considerable facility. Such is the case with the Siluroid fishes. Professor Jeffries Wyman, who spent a part of the last season in Surinam, informs me that while there he made some experiments on this subject. Some fishes were brought him, I think of the genus Calichthys. He placed them upon the floor, and found that when their fins were at liberty, they were able to work their way with considerable facility; but when these were tired, they could not advance. He learnt, also, from the natives, that this fish not unfrequently takes an excursion on land, as has been stated by authors.

Now it occurs to me whether by flapping its fins and wriggling its body, some such impression might not have been left as Plate XXV., figs. 1 and 2 present. Whether the Siluroid fishes, or any other, have any such structure in their fins as this impression exhibits, I am too little of an ichthyologist to determine. I confess I have not seen any; but the suggestion of such an origin to this track, may at least lead to more careful observation upon the tracks of the lower tribes of animals.

Species 2. Ptilichnus typographus. (Nov. Sp.)

Track consisting of one row of small, irregularly arranged impressions, say an inch wide, resembling some sorts of writing or printing. Parallel to this belt, we have one, and perhaps two rows of dots.

Remarks.— I am unable to give an outline, or any other drawing of this species, or even to describe it with accuracy, as I saw it only a few days ago, (December 8th, 1857,) in Mr. Field's collection, and had no time to take a sketch of it, or to describe it. I saw, however, that it belonged to the genus Ptilichnus, and is different from any other species; and therefore I name it, and give this imperfect account. Others must complete the description.

Species 3. Ptilichnus pectinatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{20}{6}$, $\frac{36}{50}$.]

Impressions consisting of parallel, slightly curved grooves, between one and two-tenths of an inch wide, those in the middle rather the longest, so as to form a crest somewhat arched upward. The individual grooves often show a succession of small circular indentations, looking like chains of rings. Width of the whole comb-like impression or trackway, 1.5 inch.

An outline sketch of this impression is given on Plate XXV., fig. 9. The locality is the same as that of the other species.

Remark.— I have more doubt as to the organic origin of this impression than of any other species of the genus. It is possibly the work of water. I can only say, that I have not seen its like, where I could be confident of its aqueous origin. It certainly resembles the other species of Ptilichnus.

Species 4. Ptilichnus hydrodromus, (from ὑδϱοδϱομος, literally, *running in water;* i. e. swimming.)

Ichthyopodolites of Dr. Buckland. Philosophical Magazine, March, 1844, p. 230.

[In the Cabinet, Nos. $\frac{20}{9}$, $\frac{34}{26}$.]

Five furrows crossing the summits of ripple marks at right angles, and not reaching the intervening depressions. Number of lines not exceeding seven, and appearing as if made either by the impression of a comb-like body, or the dragging of points across the ridges. Distance from ridge to ridge of the ripple marks, 2 to 2.5 inches. Width of the trackway, 0.9 inch.

Plate XXVI., fig. 5, which is of the natural size, will convey an idea of these track-ways as they exist on No. $\frac{20}{9}$ of the Cabinet.

Locality.—Turner's Falls, at Lily Pond.

Remarks.—Whatever may be thought of the origin of the other species of Ptilichnus, no good observer will hesitate to say that these markings were made by some animal swimming over the spot, either by dragging along its organs of locomotion or defence

through the mud, or sticking them down so as to reach the ridges—more likely the former. And since the markings have some resemblance to the spring rays of a fish's fin, I venture to refer them to such a cause. This discovery, in fact, which was not made till just before the completion of these details, (December, 1857,) forms the strongest argument for the ichthyc origin of the Ptilichnans.

II. SUB-KINGDOM, INVERTEBRATA.

GROUP IX.—CRUSTACEANS, MYRIAPODS AND INSECTS.

Remarks.—The Ichnological Cabinet contains quite a number of tracks which seem to have been most probably made by animals belonging somewhere in these three classes. But in the present state of our knowledge, I hold it to be quite impossible in all cases to determine in which class they should be placed. I, therefore, group them together, and under the several genera shall intimate to what family the affinities derived from the tracks, point. In the conclusion I shall have the pleasure of presenting the opinions of some eminent men of science on this point, so far as they could judge of it from drawings.

Genus I.—HARPAGOPUS, (ἁρπαγη, a drag, and πούς, a foot; the drag-form foot.)

Feet didactylous; toes unequal in length; divaricate; more or less like the sides of a triangular harrow or drag.

Species 1. Harpagopus Hudsonius.

Harpagopus Hudsonius. Fossil Footmarks of the United States, Plate XVIII., fig. 2.

[In the Cabinet, No. $\frac{10}{2}$.]

Toes diverging about 40°; unequal in length; blunt or rounded. Length from 2 to 3.5 inches; axis of the toes when walking, placed nearly at right angles to the line of direction. Rows of tracks two, about a foot apart. Distance between the successive pairs of toes in walking, inconstant. Width of the trackway, 17 inches.

An ambrotype sketch of the only slab in the Cabinet, No. $\frac{10}{2}$, is given on Plate XLIX., fig. 6.

Locality. — This is the only example in this Report, except a species of Batrachoides, in which I have described a track out of New England. It comes from the famous flagging stone quarries on Hudson River, and the rock belongs to the Hamilton Group of the Devonian Rocks. I found the specimen in the sidewalk in one of the streets of New York, and obtained leave to remove it. I had some doubt whether it were a real track; but I have often seen it on the widely diffused flagging stone of the Hudson River quarries, and it bears a close analogy to some impressions on the much more recent rock of the Connecticut Valley. I thought, therefore, it might be well to give this short account of it and present one ambrotype sketch.

Nature of the Animal. — On this point I have not much to say, because I know but little. The tracks must have been made, if I have rightly apprehended their character, by

an animal that spread out its legs nearly at right angles to the course on which it was walking. The feet seem to have been didactylous; and this is the chief reason why I suspect the animals to have been Crustaceans, some of whose extremities are didactylous. But I know of no living Crustacean that would make such tracks; nor am I acquainted with the tracks of living Crustaceans; and, therefore, I feel very little confidence that this animal really belongs among them.

Species 2. Harpagopus dubius.

Harpagopus dubius of Fossil Footmarks of the United States; Plate XVIII., fig. 2.

[In the Cabinet, Nos. $\frac{32}{9}$, $\frac{32}{46}$.]

Feet from 1.25 inch to 2.25 inches long, and 0.5 inch wide, with rounded extremities. Impressions arranged along a line, with which their axes make an angle of about 50°; consequently the tracks are parallel to one another, at distances varying from half an inch to two inches. Form of the impressions almost exactly that of the human foot, showing a heel and ball of the foot. The heel, however, is sometimes entirely separated from the ball, and the front part becomes somewhat trilobate.

An ambrotype sketch of this species is given on Plate LI., fig. 5.

Locality. — On black shale from Turner's Falls from whence the specimen No. $\frac{32}{9}$ was obtained many years ago by Dr. Deane and presented to me. Also at South Hadley Canal(?) No. $\frac{32}{46}$.

Remarks. — I have so little confidence that this an animal's track that again and again I have resolved to strike out the species. But on re-examining the specimen, (unfortunately too small to give a full idea of the tracks,) and finding it so difficult to refer them to any other agency, I determine to let it remain; and this is my final decision after this strong expression of my scepticism. And I leave it, as in the Fossil Footmarks of the United States, chiefly in the hope that it may lead others with better specimens to determine their true nature.

In re-examining these specimens, for this Report, I am struck with the resemblance between the form of this impression and that of the human foot, covered with a shoe. It corresponds almost exactly with specimens found at the Portland quarries of the size of the largest man's foot, and which have been announced in the newspapers as indeed of human origin. I have given some account of these under the species Cunichoides marsupialoideus, and two reduced figures of them (3 and 4) are given on Plate LX. I have added two of the impressions of Harpagopus dubius of the natural size, to show how strong is their resemblance to the Portland supposed human tracks when reduced. One of them, fig. 6, like the Portland track, fig. 4, has another and smaller impression a little in advance probably (possibly in *the rear*) of the principal one. This has been overlooked in the Portland specimens, although I doubt not the two impressions were made by the same foot, with an arch beneath it, that prevented its whole length from reaching the ground. This fact effectually refutes the popular opinion that this is a human track, if it needs refutation, as it hardly does, among scientific men. But by what animal it was made I feel entirely

ignorant. Probably only one of the tracks has yet been brought to light; when the whole made by the animal with all its feet on the ground, shall be found, probably the affinity to some living race may be obvious. My present opinion is, that the Portland tracks and the Harpagopus dubius were made by animals (or plants?) of the same general character, but differing enormously in size.

Genus II.—STRATIPES, (*Sterno*, to spread out, and *Pes*, the foot; the animal with sprawling feet.)

Animal's feet perhaps didactylous; spread out in walking nearly at right angles to the line of direction.

Species 1. Stratipes latus. (Nov. Sp.)

[In the Cabinet, No. $\frac{13}{4}$.]

Feet probably bifid, but possibly unidactylous; the hind foot, if it be so, being brought up very near the fore foot at each step. The first supposition is here assumed as the true one. Toes somewhat curved, and lying nearly parallel; length from 3 to 4 inches. Distance between successive imprints of the same foot, 9 to 13 inches, which is the length of the step. Distance between the outer extremities of the right and left feet in walking, or width of the trackway, 27 inches; do. between the inner extremities, about 20 inches. Hence the body of the animal may have been from 12 to 15 inches wide.

An ambrotype sketch of slab No. $\frac{13}{4}$, with two rows of this animal's tracks, is given on Plate XLIX., fig. 4. The length of the rows is over 6 feet.

Locality.—Turner's Falls, in Mr. Field's orchard. This track is upon the upper side of one of the best slabs of tracks ever obtained. Dexter Marsh got out two specimens, one depressed, the other in relief; the former about a foot the widest. This was covered with nearly a hundred very distinct tracks, and at the auction of Mr. Marsh's Cabinet, was bought by the Boston Society of Natural History, but its counterpart was bid off for the Amherst Ichnological Cabinet, No. $\frac{13}{4}$. It was not till I was putting it up in that Cabinet, that I discovered the tracks of the Stratipes on the other surface. Scarcely any other tracks exist on the same surface, and it appears to me as if the surface was beneath the water when the animal trod upon it, and hence the tracks are not well defined. Yet on the other surface of the slab, only two inches lower down, we have over 70 tracks, remarkable for their distinctness, and which must have been made on shore. The mud which filled them may have been quietly silted in by the tide, and then some amphibious creature have partly swam and partly walked over the bottom. The surface has a certain roughness which is not common where the mud is sun-dried and trod upon while above the water.

Nature of the Animal.—We are struck in looking at this specimen with the general distinctness of its outline, and see at once that it is different from any other in the Cabinet. But when we attempt to refer it to a particular class of animals, we find great embarrassment. At first, perhaps, we think of a huge marine tortoise, swimming along and striking the bottom with its feet. But I can find no living tortoise whose extremities bear any

resemblance to those of the Stratipes. They all have five toes, though in some species so united and covered that they would make but one impression, yet not one so narrow as in this case. Some Crustaceans have bifid extremities to their organs of locomotion, and on this ground alone have I conjectured this animal to belong to this class. But I know not whether in walking or crawling over the surface, crustaceans make impressions at all analogous to those of the Stratipes. With eight or ten feet, I should presume they do not. But if this were not a giant Crustacean, I know not what he was, and will not multiply words about him.

Genus III.—HAMIPES, (*Hamus*, a hook, and *Pes*, the foot; a hook-like foot.)

Foot didactylous; toes curved inward, so as to be somewhat hook-shaped.

Species 1. Hamipes didactylus. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{16}$.]

The didactylous imprints of the feet in walking are arranged in two parallel rows, 1.4 inch apart. Axis of the foot nearly coincident with the line of direction, but generally turned a little outward. Toes nearly parallel, sometimes slightly divergent; distant from each other, 0.1 inch; length, 0.5 inch; width scarcely more than that of a hair. Foot digitigrade. Length of the step from track to track, apparently of the same foot, 0.6 inch. Width of the trackway, 1.62 inch.

This track is shown of the natural size on Plate XXV., fig. 8. Indeed, the whole of the only specimen in the Cabinet is here shown.

Locality.—Turner's Falls, on Mr. Field's farm.

Nature of the Animal.—Its track very much resembles the bifid extremities of the King Crab, or Limulus Polyphemus of our coasts. But this animal has at least four feet on each side, which it must use in walking; and it seems incredible that the tracks would form such regular rows with equidistant steps, as the Hamipes presents. Yet the resemblance above referred to, may justify me in leaving the animal among the Crustaceans provisionally. It is a very distinct and peculiar track, like that of the Stratipes; and a glance at it shows us that it differs from all others in the Cabinet. But whether the whole story is told by this specimen, may admit of doubt.

Genus IV.—ACANTHICHNUS, (ἄκανθα, a prickle or spine, and ἴχνος, a track; the prickly track.)

Tracks linear; in two parallel rows.

Species 1. Acanthichnus cursorius. (Nov. Sp.)

Figured without a name by Dr. J. Deane, in the Journal of the Academy of Natural Sciences, Plate 19, f.

[In the Cabinet, Nos. $\frac{36}{19}$, $\frac{36}{20}$, $\frac{36}{21}$, $\frac{36}{24}$.]

Distance between the rows of tracks, 0.18 inch. Tracks opposite, diverging a few degrees; length of the foot, 0.15 inch. Length of the leap, varying from 0.1 inch to 0.8 inch.

Several rows of the tracks of this species, of the natural size, are shown on Plate XXVIII., fig. 1, and on XXXI., fig. 1.

One of the most striking peculiarities of this species is the great difference of its leap; it being eight times longer in some instances than in others.

Locality.—Turner's Falls, Lily Pond.

Species 2. Acanthicnus saltatorius. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{34}$, $\frac{36}{20}$, $\frac{36}{45}$.]

Distance between the rows of tracks, 0.1 inch. Tracks opposite, nearly parallel. Length of the foot, 0.08 inch; of the leap, from 0.08 to 0.18 inch. Animal frequently jumping sidewise, as a dancer; and hence the specific name. This character and the extreme shortness of the leap in some cases, distinguish this species from A. cursorius.

Two rows of the tracks of this species are shown on Plate XXVIII., figs. 4 and 5, of the natural size. Fig. 4 might perhaps pass for A. cursorius; though I have not seen the lateral hop in the last species. But fig. 5 is evidently a distinct species: distinct, perhaps, even from fig. 4.

Locality.—The same as that of the preceding species.

Species 3. Acanthichnus tardigradus. (Nov. Sp.)

Figured without a name by Dr. J. Deane, in the Journal of the Academy of Natural Sciences, Plate 19, g.

[In the Cabinet, No. $\frac{36}{19}$.]

Width of the two lines of tracks, 0.33 inch. Length of the tracks, 0.15 inch. Tracks turned outward from the median line, from 15° to 20°. Distance between the successive tracks, 0.1 inch to 0.25 inch. Feet linear, acuminate; tracks opposite. Width of the trackway, 0.48 inch.

A sketch of the tracks of this species of the natural size, is given on Plate XXVIII., fig. 1.

Locality.—The same as that of the two preceding species.

Nature of the Animals of this Genus.—The existence of only two rows of tracks turned a little outward, and generally quite numerous, has led me to inquire whether these animals may not be Myriapods. Plate LV., fig. 4, is an ambrotype sketch of the trackway of a small worm on clay, discovered by Charles H. Hitchcock, in Hadley; and I have been inclined to regard it as a Myriapod, perhaps an Iulus, with very delicate feet, though it is quite possible that the bristles upon some Annelids might make the lateral impressions. This specimen shows at least, that the feet or hairs upon very small worms may make a distinct and permanent impression upon clay, as an inspection of No. $\frac{48}{40}$ in the Cabinet will show.

I confess that the apparent mode of progression with the species of this genus, if we understand it, does not correspond with that of a Myriapod, or an Annelid. For it seems from the feet being opposite, that it must have been by leaps, and the length of the

leaps seem to have varied, as the Plates will show. It may be more probable therefore that the animal was a Crustacean; yet it seems as if it used only two feet in moving forward, and I can hardly conceive how this should have been done by one of these animals.

Some able writers (see Siebold's *Anatomy of the Invertebrata*, Boston, 1854,) make Myriapods one of the Orders of Crustacea; others regard them as more properly a family of insects. Very possibly we may never be able certainly to distinguish Myriapods from certain crustacean or insect forms by their tracks.

GENUS V.—CONOPSOIDES, (*κώνωψ*, a musquito, and *εἶδος*, appearance. To complete the idea of the name, we must bring in that of the species, namely, *larvalis, of a larva;* and the meaning will be, a track resembling the larva of a musquito.)

Tracks in three, and probably four rows; divergent from the median line. Foot blunt at its anterior part, and so striking the mud in walking as to elevate a tubercle.

Species 1. CONOPSOIDES LARVALIS. (Nov. Sp.)

Figured without a name by Dr. J. DEANE, in the Journal of the Academy of Natural Sciences, Plate 19, b and c.

[In the Cabinet, No. $\frac{36}{25}$.]

Breadth of the trackway or space occupied by the rows of tracks, 0.8 inch. Divergence of the outer rows of tracks, 15° to 40°. Length of the tracks, 0.2 inch. Length of the step, or leap, 0.3 to 0.5 inch. Foot linear, its track terminated usually in front by a slight mound of mud raised by the slipping forward of the foot, as it would do in leaping. Tracks in pairs on each side of the median line, the inner row less divaricate than the outer one. Rarely more than two rows of tracks, and those only on one side of the median line visible; sometimes a part of the third row is shown.

Rows of these tracks are shown on Plate XXIX., fig. 6, and Plate XXX., fig. 4, of the natural size.

Locality.—At Turner's Falls, on Mr. FIELD's farm, and found by him. Also on the gray shale of Wethersfield.

Remarks.—The tracks of this species strikingly resemble the larvæ of the mosquito, seen so often in the summer in stagnant water, and hence the name. Not that I suppose any resemblance in nature to the animals; for the track is not the animal. Had I not found occasionally part of a third row of tracks, I might have suspected the animal to be a Myriapod; but now I feel almost sure that it had more than one row of feet on each side; though I have never seen but three rows of tracks. It may have been a small Crustacean; but until more observations have been made upon the tracks of living Crustaceans, (I have myself seen none,) the suggestion may be little better than conjecture.

GENUS VI.—BIFURCULAPES, (*Bis*, twice, *Furcula*, a little fork, and *Pes*, the foot; the double, small-forked foot.)

Four regular rows of tracks made in walking, which, when united, as they often are at the base, resemble small forks. Two additional rows sometimes visible, as on Plate XXX., fig. 1.

Species 1. Bifurculapes laqueatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{28}$, $\frac{36}{19}$, $\frac{36}{32}$, $\frac{36}{33}$, $\frac{36}{48}$.]

Width of the trackway or the double rows of forks, or lines of tracks, 0.3 inch. Do. between the tines of each fork, 0.1 inch. Length of the feet or tines, 0.1 inch. Tracks generally following one another in close succession, with no perceptible interval, and never separated more than 0.1 inch. Outer prong of the fork frequently curved inwards strongly. Prongs of the forks sometimes united at their base, but not often. The animal sometimes so doubled upon its course when walking, as to form graceful loops. (See Plate XXX., fig. 3.) Pairs of tracks opposite. An additional row of tracks is sometimes seen placed near the forks. Plate XXX., fig. 1.

Good specimens of this species are represented of the natural size on Plate XXX., figs. 1, 2, and 3. The specimens from which these sketches were taken, are most of them very fine and give a striking idea of the perfection to which this process of preserving tracks was carried sometimes. Of the tracks now made by insects or crustaceans no larger, probably not one in a million is preserved by being covered with a layer of mud, so that it would be petrified. But here we have long rows of hundreds of tracks, with only a few wanting. How many things must have conspired to secure such preservation. Nos. $\frac{36}{33}$, $\frac{36}{28}$ and $\frac{36}{19}$ in the Cabinet are particularly fine.

Locality. — On Mr. Field's farm, at Turner's Falls.

Species 2. Bifurculapes tuberculatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{19}$, $\frac{36}{46}$, $\frac{36}{47}$, $\frac{36}{45}$.]

Width of the trackway on the double lines of tracks, 0.5 inch from the outer extremities of the tracks; between the inner extremities, 0.25 inch. Length of the inner foot, or tine, of the fork, 0.15 inch; of the outer tine or foot, slightly less; of the leap or step, 0.25 inch. Pairs of feet opposite. Posterior part of the inner foot tubercular, the process making a deeper impression.

Plate XXX., fig. 4, shows an outline of this species. The tubercle is the part most permanently impressed. Hence sometimes we see on the track little else than a row of tubercles.

Locality. — Mr. Field's farm.

Species 3. Bifurculapes scolopendroideus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{14}$, $\frac{36}{45}$.]

Width occupied by the two rows of forked feet, 0.9 inch, from the outer extremities of the tracks. Width of each row, 0.3 inch. Feet broad, linear, acuminate. Divergence between the prongs of each fork, 25° to 30°. Outer prong turned outward from the median line, 20° to 35°. Inner prong turned inward from 5° to 20°. Length of the outer foot, or prong, 0.45 inch. Do. of the inner, 0.25 inch. Outer feet curved some-

what inward. Inner foot or prong frequently wanting in the tracks. Distance between successive impressions, 0.5 inch. Forks opposite.

An outline sketch of the best specimen of this species in the Cabinet, is given on Plate XXVII., fig. 1.

Locality. — Turner's Falls, on gray shale below the cataract, found by Dexter Marsh.

Remarks. — So seldom does the inner prong of the fork appear on this specimen that I at first regarded the animal as having only two rows of feet, and thought it might be a Myriapod. But on closer examination the forked arrangement of the feet is too obvious to be mistaken, although less decidedly so than in the other species of this genus; and I accordingly place it with the Bifurculapeans. The two prongs of the fork, however, do not appear to proceed from the same foot, as may be the case with the species already described; and the inner one is so short and so frequently wanting, that the tracks reminded me of what I should suppose would be the tracks of a Scolopedendron, and hence the specific name. But it conveys a wrong impression, since no centipede has a forked foot, or two feet so placed that they would leave a forked track. Whatever was the nature of the animal, there can be no doubt but it is quite distinct from any that has been described.

Species 4. Bifurculapes elachistotatus. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{17}$.]

Width of the space embraced by the whole four rows of tracks, 0.4 inch; do. by each pair, 0.15 inch; do. between the inner rows, 0.1 inch. Outer rows diverging a few degrees. Inner rows nearly parallel to the median line. Length of the track, 0.05 inch; do. of the step, 0.2 inch. Pairs of tracks alternate, hence the animal must have moved by steps rather than leaps. Tracks in pairs, but entirely disconnected apparently.

On Plate XXIX., fig. 4, a specimen of this track is shown of the natural size, along with another insect track to be described, and a number of the scales of a coniferous plant. I have been struck with the resemblance between these plant markings and the small scales on the surface of a young branch of the American Larch (*Pinus pendula.*) They occur on several other specimens, and coniferous twigs are the most common of the vegetable impressions on these rocks. On Plate XXXI., fig. 1, we find seeds also; and in the beginning of this Report, I have described and figured a cone from our sandstone.

Another much longer low of the tracks of this species is shown on Plate XXX., fig. 3, copied from a fine specimen in possession of Mr. Field.

Locality.—Turner's Falls, Lily Pond.

Remarks.—We have now reached the smallest of all the fossil footmarks, so small that few persons would discover them. Yet when carefully traced out we find them as little defective as the large tracks, and probably from their simplicity, more perfect. I calculate, not with entire accuracy of course, that it would require nearly half a million of these smallest tracks to fill the same space as one track of the hind foot of the Otozoum! To designate so small a track appropriately has not been easy. I have chosen, perhaps not in exact accordance with the rules for naming objects in natural history, a Greek adjective

that signifies *less than the least.* This to be sure is a solecism, but it aptly describes one's feelings when looking at such tracks.

Nature of the Animals of this Genus.—The great regularity and distinctness of the forks in the tracks of this genus awakens two inquiries: first, whether each fork is not made by the bifid extremity of a single foot, rather than by two feet? secondly, had the animal any more feet than sufficient to make these forked tracks? A single specimen,—one of our best,—sketched on Plate XXX., fig. 1, gives a probable answer to both these inquiries, showing on one of the trackways, the tines of the forks so separated as could not have been done if made by a single bifid foot, and also showing several examples of a third row of tracks. I think we may be certain, therefore, that the animal had at least six feet. Perhaps I ought to except the B. elachistotatus, which has an almost parallel arrangement of the tines of the fork, and differs, moreover, from the other species by an alternate arrangement of the pairs of tracks. In the other species they are nearly opposite, as if the animal moved by leaps. But the steps are too short to be regarded as leaps, and I confess that it is not an easy matter to conceive how an animal with many pairs of legs should have advanced by steps so short yet nearly equidistant. Yet annelids seem to have the power of thus walking, if the tracks on clay, shown on Plate LV., fig. 4, were made by such an animal. And were there in the Bifurculapes the trail of a body between the rows of tracks, as in the case on clay, we might perhaps presume this genus to have been annelidan.

Upon the whole, I think the question lies between crustaceans and insects. If we were sure that all of them had six feet, it would be a strong argument for their insect character. But perhaps the usual presence of only two rows of forked feet on the tracks, and the semilunar character of some of the tracks, (shown imperfectly in the drawings,) should lead rather to the Crustaceans. Yet, alas, how difficult to form an opinion on evidence so slight! What fool cannot raise difficulties enough to stop our mouths? But where are the wise men to solve the enigma? They will appear, however, when the way is prepared; and then how weak and puerile will our conjectures appear, who make the first efforts to let the light in upon the midnight!

Genus VII.—GRAMMEPUS, (γϱαμμή, a line, or stroke in writing, and πούς, the foot; a foot resembling the lines in writing.)

Tracks arranged in two parallel rows, the principal ones forming almost continuous lines, parallel to the line of direction. The two other tracks short, lying outside, and forming various angles with the median line.

Species 1. Grammepus erismatus. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{39}$.]

The principal lines of tracks separated 0.7 inch; parallel to each other and to the median line. Length of the track, 0.5 inch; width, one-twentieth of an inch. Length of the step, 0.8 inch. (?) Second track, 0.3 inch long, diverging from the first about 30°.

Third do., 0.2 inch long, lying nearly at right angles with the line of direction, the two outer tracks seeming like buttresses or supports to the other, and hence the specific name, *erismatus*, from *erisma*, a buttress. Width of trackway, 1.2 inch.

Plate XXIX., fig. 1, presents an outline sketch of this species copied from the only specimen in the Cabinet, No. $\frac{36}{39}$.

Locality.—Turner's Falls, on Mr. Field's farm.

Nature of the Animal.—The specimen which we possess of the tracks of this species has not all the distinctness and certainty about it which I could desire, yet I think I see in the tracks some evidence that they may have been made by a stout hexapod insect. Crustaceans are the only other class, I think, to which any will be inclined to refer them.

Species 2. Grammepus unordinatus. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{38}$.]

Tracks arranged in a single row, the principal one forming an almost continuous furrow from one-thirtieth to one-twentieth of an inch wide, like that produced by an annelid. The other tracks somewhat divergent on either side. Number of feet uncertain. Width of the trackway, 0.2 inch.

Locality.—Turner's Falls, Mr. Field's farm.

An outline of this track of the natural size is given on Plate XXIX., fig. 2.

Remarks.—It may be doubted whether this species is worth giving, as we have but a single specimen, which, though distinct, is not all we could wish. I doubt whether this animal belongs to the genus Grammepus, because it shows only one row of tracks. But the impressions have a good deal of resemblance to those of the Grammepus erismatus, and I leave the two together until further light is obtained.

Genus VIII.—LITHOGRAPHUS, (λίθος, a stone, and γράφω, to grave or write; an engraver on stone.)

Hexapod; longest tracks in parallel rows, and between the shorter ones. Outer track crooked, so as to become even forked. Inner one shortest.

Species 1. Lithographus hieroglyphicus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{26}$, $\frac{36}{18}$.]

Longest tracks forming two almost continuous lines, parallel to each other, at the distance of 0.4 inch. Length of this track, 0.2 inch. Longest horn of the crooked track diverging from the median line from 30° to 40°. Shortest horn turning towards the median line. Length of the steps, 0.3 to 0.4 inch. Width of the trackway, 0.8 inch.

An outline sketch of a row of this track is given on Plate XXIX., fig. 3. Another less perfect is shown on Plate XXXVII., fig. 2.

Locality.—Turner's Falls, Mr. Field's farm.

Remarks.—An examination of the specimen of this species above referred to, recalled to my recollection another from the red shale of Wethersfield, which I had collected many years ago, and of whose nature I had never been satisfied. On re-examination I

concluded either that it was a fossil plant, probably a sea-weed, or an insect track. I became convinced that it was the former, and then the question arose, whether all the supposed insect tracks are not plants. If this species were the only one known, I could easily be persuaded that such is the case. But an examination of all the species will, I think, satisfy any one that most of them at least must be tracks. That we are liable to confound the two things, I admit; for there are fossil plants in this sandstone which I have not attempted to describe, that have been referred to tracks by experienced judges. But the experienced naturalist should not, through fear of falling into such an error, be led to overlook real differences where they exist; and such will surely meet him between most of the minute tracks which I am describing, and fossil plants.

Another fact operated for a time to throw doubt over the ichnological character of these minute markings. As a general principle I had regarded it fatal to the idea that impressions were tracks, if made on the under side of the layers; that is, if the impression was arched upward; yet in the Bifurculapes tuberculatus, I found tubercles on the same surface where the greater part of the markings were depressions; and the suspicion was strong, that they were produced by a body interposed between the layers of mud, and not by animals walking over the surface. But I have learnt that sometimes the animal, by thrusting its foot forward, or crowding it backward, does raise little piles of mud, and when afterwards other mud is brought over the spot, it will fold down over these tubercles, and thus produce an impression upwards. I think, though not wholly free from doubts on the subject, that such was the case with the Bifurculapes tuberculatus.

Upon the whole, I retain a belief that we have small crustacean and insect tracks on the shale of this valley. But it is well to keep our eyes open to every other possible mode of explanation; and since I have said so much here, I think it best to present an ambrotype sketch of the specimen from Wethersfield, above referred to, which I should now label a sea-weed; and it is shown on Plate XXIX., fig. 5.

Species 2. Lithographus cruscularis. (Nov. Sp.)

Figured without a name, by Dr. J. Deane, in the Journal of the Academy of Natural Sciences, Plate 19, d.

[In the Cabinet, Nos. $\frac{36}{17}$, $\frac{36}{18}$, ? $\frac{36}{35}$.]

Distance between the two principal rows of tracks, 0.15 inch. Length of the tracks in these rows, 0.1 inch. Length of the step, 0.18 inch. Width of the trackway from tip to tip of the outer or crooked feet, 0.4 inch. Length of the inner and shortest foot one-twentieth of an inch; placed on the track just at the roots of the crooked foot Width of the trackway, 0.35 inch.

An outline of two specimens of this species is given on Plates XXIX., fig. 4, and XXX., fig. 3.

Locality.—Turner's Falls, with the last species; from which this differs chiefly as to size.

Nature of the Animals of this Genus.—This is the first genus in which I find certain evidence of six legs,—the normal number possessed by insects. I suspect that these

animals were such. The crooked foot, as shown by the tracks, must, I presume, be exhibited on the tracks of many living species of this class of animals. But after all these tracks have quite a crustacean aspect.

GENUS IX. — HEXAPODICHNUS, (ἕξ, six, πούς, a foot, and ἴχνος, a track; the six-footed track.)

Tracks arranged by threes, in rows on each side of the median line; the inner tracks running nearly parallel to that line. Outer tracks parallel, or diverging outwards. Alternate on opposite sides of the median line.

Species 1. HEXAPODICHNUS MAGNUS. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{11}$.]

Principal tracks by twos and in alternation on opposite sides of the median line. Distance between them, 0.34 inch. Width of the whole trail or trackway, 0.8 inch. Length of these tracks, 0.2 inch; do. of the step, 0.25 inch. Third set of tracks small, irregularly placed, and seldom seen on the only specimen yet discovered.

An outline sketch of this species, copied from No. $\frac{36}{11}$, may be seen on Plate XXIX., fig. 7.

Locality. — Turner's Falls, Lily Pond.

Remarks. — The arrangement of the tracks of this species by alternating pairs, and the rarity of the impression of the third foot, led me for a time to reckon this specimen among the species of Bifurculapes. But I think I discover the third track occasionally, and if it exist, it removes the specimen out of the four-footed genera. However, I am by no means certain that I am right. If not, this species should become Bifurculapes magnus.

Species 2. HEXAPODICHNUS HORRENS. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{33}$.]

Longest tracks arranged in rows on each side of the median line, and distant from each other, 0.25 inch. Length of these tracks, 0.1 inch. Length of the step, 0.4 inch. Width of the whole space impressed, or the trackway, 0.6 inch. Outer row of tracks, which are the second in length, 0.1 inch long. Divergence of these tracks outward, about 40°; distance of this outer row of tracks from the inner row on the same side of the median line, 0.1 inch. Position a little in advance of the inner row. The shortest track, 0.06 inch long, lies between the outer and inner tracks, but a little in advance, and diverges outward about 10° less than the outer toe, so that the two outer toes form a fork, the inner prong the shortest.

This species is shown of the natural size, on Plate XXX., fig. 1, along with the Bifurculapes laqueatus, as they appear on the fine specimen, No. $\frac{36}{33}$.

Locality. — Turner's Falls, Mr. Field's farm.

Nature of the Animals of this Genus. — The second species of this genus is one of the most perfect and delicate of all the insect tracks yet discovered, although only a single specimen has been seen by me; but it is quite satisfactory. Though the tracks are very

small, they are quite distinct, and placed so far from one another that they are not liable to be confounded. It is quite obvious that the animal had six feet, and this fact excites a presumption in favor of its insect origin. Perhaps a good entomologist might be able to refer it to its place among the orders of this class. Yet I fancy that more progress must be made in the ichnology of insects, and indeed in that of all the invertebrata, before the most accomplished zoologist can speak with much confidence on such a point. Indeed, such an one might rather maintain, and not without reason, that these animals may have been crustaceans and not insects.

Genus X.—COPEZA, (*κώπη*, an oar, and *πέζα*, a foot; the oar foot.)

Feet six; the tracks arranged in triple rows on each side of the median line; the principal track being placed at right angles to that line, as oars on the sides of a boat when in use.

Species 1. Copeza triremis. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{37}$.]

Distance between the two principal rows of tracks, which lie at right angles to the median line, 0.8 inch. Length of those tracks, 0.1 inch. Distance between the outermost rows of tracks on the trackway, 1.4 inch. Outermost row nearly parallel to the median line and somewhat in advance of the tracks of the inner rows. Length of the tracks in the outermost row, 0.1 inch; do. of those in the middle row, 0.07 inch. Tracks of the middle row lying between the other rows, with a divergence from the median line of some 20°. Length of the step, 0.44 inch.

An outline of the two rows of tracks of this species, copied from No. $\frac{36}{37}$, is given on Plate XXXI., fig. 4. Other insect tracks of the same species exist on this specimen, but to avoid confusion I have exhibited only the most obvious rows. The tracks on the right side are obviously the most perfect, those on the other side having been somewhat interfered with by other tracks.

Locality.—Turner's Falls, on Mr. Field's farm.

Remarks.—The specimen containing this interesting genus, was overlooked till the latest moment for a place in this Report. The number of tracks upon the slab produced some confusion, and it was not till after a careful study that I got the clue to the true order. The position of the principal tracks at right angles to the median line, suggested the idea of oars, for I perceived that probably the animal propelled himself forward over the mud just as oars urge forward a boat. Hence I gave the name Copeza to the genus; and on observing the arrangement of the three feet in walking, it seemed to me appropriate to add *triremis* as a specific name, which means *three-oared;* so that the whole name, I trust not improperly, may be called *the three-oared oar foot.*

Nature of the Animal.—The tracks of the Copeza seem to me more like those of an insect than any others I have described. Yet I feel the extreme difficulty of discriminating between the tracks of insects and crustaceans. Judging from the animals that are found

on the muddy shores of the present geological period, we should expect to find a mixture of the two classes; and I incline to the opinion that such was the case in oolitic days.

March 10th, 1858. Thermometer nearly at zero on Fahrenheit's scale! A strange time to be examining the tracks of living insects. But one, a little larger than a house-fly, and resembling the small *miller* so common in the summer, has been crawling over the window of my study, and I have been struck with the resemblance between the position of his six legs and the tracks of the Copeza. His two anterior feet were placed parallel to the line of direction, a little farther apart than the width of his body; then came the middle pair, which were placed nearly at right angles to the line of direction, but pointing a little backward; and the hind feet made an angle somewhere towards 45° with the line of direction pointing, also, backward. I regret that I could not devise any surface that would retain the impressions. But whatever was the nature of the Copeza, I am sure that as to form and position its tracks might properly be brought into the same family with those of this insect.

GROUP X.—ANNELIDS.

Remarks.—I have separated the following genera from the preceding wide group of invertebrates, and placed them under the Annelids, or naked worms, because their track-ways seem to me to designate their character more clearly than is the case with those already described. Yet some of them are not a little anomalous, and not easy to be distinguished by their tracks from vegetable forms.

Genus I.—UNISULCUS, (*Sulcus*, a furrow, and *Unus*, one; a single furrow.)

Trackway a continuous single groove.

Species 1. Unisulcus Marshi.

Herpystezoum Marshi, Fossil Footmarks of the United States, Plate XVII., fig. 1.

[In the Cabinet, Nos. $\frac{10}{6}$, $\frac{19}{11}$, $\frac{19}{12}$, $\frac{29}{2}$.]

Groove 0.2 inch wide; not unfrequently looped.

Shown of the natural size on Plate XXVI., fig. 1.

Locality.—Turner's Falls at the Ferry; where it was dug up by Dexter Marsh, who by indefatigable industry obtained a rich collection of fossil footmarks, which, after his death, were sold at auction, and were distributed among many of the Cabinets of the country, especially those of the Boston Society of Natural History; of Amherst College; the State Collection at Albany, and the New York Lyceum of Natural History. Mr. Marsh became quite skilful in distinguishing different species and was well known among scientific men. By over-exertion in procuring specimens of fossils and minerals, he doubtless prepared his constitution for the disease that carried him off. It is due to his memory to attach his name to some species of animal that made the footmarks; and this Unisulcus, though not one of the largest kind, has left one of the most distinct tracks. It might be supposed to be the trail of a small mollusk; but it looks rather like that of

an annelid similar to the common earth worm, or angle worm, which leaves merely a smooth furrow; whereas mollusks plough their way through the mud and leave ridges on each side of the groove.

Found, also, at the Portland quarries.

Species 2. UNISULCUS INTERMEDIUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{10}{6}$, $\frac{36}{22}$, $\frac{20}{9}$, $\frac{36}{44}$, $\frac{36}{41}$.]

Width of the groove, 0.1 inch; very crooked and often looped.

Shown of the natural size on Plate XXVI., fig. 2.

Locality.—Turner's Falls, on gray micaceous sandstone; grooves very numerous and crooked, bearing a striking resemblance to the trackways of the common earth worm on the mud after a warm rain in the summer or autumn. Discovered by Mr. FIELD.

Species 3. UNISULCUS MINUTUS.

Herpystezoum minutum. Fossil Footmarks of the United States, Plate XVII., fig. 2.

[In the Cabinet, Nos. $\frac{19}{10}$, $\frac{20}{11}$, $\frac{26}{23}$, $\frac{19}{11}$.]

Width of the groove, 0.05 inch, or one-twentieth of an inch; trackways very numerous and intertangled.

Shown of the natural size on Plate XXVI., fig. 3.

Locality.—Turner's Falls, where it was dug up by Mr. MARSH.

Nature of the Animals of this Genus.—Perhaps I have said enough on this point, under the first species; certainly I know but little about it; though the trails left by these animals on stone correspond strikingly with those of annelids, which meet us so frequently on mud during the summer.

GENUS II.—COCHLICHNUS, (κόχλος, a screw, or snail, and ἴχνος, a track; the screw track.)

Trackway a continuous serpentine furrow, resembling a compressed corkscrew.

Species 1. COCHLICHNUS ANGUINEUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{19}$, $\frac{36}{40}$.]

Chord of the right and left curvatures of the trackway, 0.3 to 0.75 inch. Width of the trackway, about the thirtieth of an inch; broader in that part of the curve against which the animal must have pressed the hardest, in advancing like a snake; which must have been its mode of progression. Double versed sine of curvature, or double the distance of the curves from the median line, 0.1 to 0.35 inch. Spire not unfrequently gradually diminishing towards one extremity.

Outlines of several of these trackways of the natural size are shown on Plate XXVI., fig. 6. A fine example may also be seen on the slab belonging to the heirs of Dr. J. C. WARREN, of which a sketch is given on Plate XXXVII., fig. 4.

Locality.— Turner's Falls, on Mr. FIELD's farm; of course quarried out by him.

Nature of the Animal.—The regular and even graceful curvature of the trackway to the right and left, is the grand distinction between this animal and the Unisulcus; and I must think that it indicates a generic distinction without doubt. Nay, although I have placed this genus among the Annelids, its track may have been formed by such an Entozoan as the Gordius, or hair worm. By means of the hairs or bristles upon the Annelids they are able to advance nearly on a right line; but though their path is often crooked and looped, I have never seen one made by a living Annelid that indicates a mode of progression so very like that of serpents as in the case of the Cochlichnus.

Genus III.—COCHLEA, (κοχλίας, a spiral or screw.)

Trackway somewhat resembling a double screw or spiral.

Species 1. Cochlea archimedea. (Nov. Sp.)

[In the Cabinet, No. $\frac{36}{49}$.]

Trackway resembling an Archimedean screw, though not exactly. Width of the groove, 0.2 inch. Width of the whole surface covered by the furrows, 0.7 inch. Distance from curve to curve on the same side, 0.7 inch.

Outline of the trackway shown of the natural size on Plate XXVI., fig. 9. An ambrotype sketch of the same is given on Plate XLIX., fig. 7.

Locality.— Turner's Falls, Lily Pond.

Remarks.—The trackway of this species is so peculiar that I find it very difficult to conceive how it was formed; and it is quite possible that I may have mistaken its character in putting it down as a species of Annelid. But I can see in the single specimen as yet found, no affinity with any other footmark, nor explain it by any other than an organic agency.

Genus IV.—HALYSICHNUS, (ἅλυσις, a chain, and ἴχνος, a track; the chain track.)

Trackway with ridges on each side; as if the animal had ploughed its way through the mud instead of gliding over the surface; crossed at intervals by depressions, giving to the pathway the appearance of a chain.

Species 1. Halysichnus laqueatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{33}{35}$, $\frac{16}{4}$.]

Length of the links of the trackway, 0.3 to 0.7 inch. Width, including the ridges, 0.1 inch. Links slightly the widest in the middle. Pathway repeatedly looped, as the specific name implies.

Outline of the pathway of this species shown of the natural size on Plate XXVI., fig. 7.

Locality. — Turner's Falls, Lily Pond; on light colored shale.

Species 2. Halysichnus tardigradus. (Nov. Sp.)

Length of the links of the trackway, 0.2 to 0.25 inch; width, 0.05 inch. Tracks looped.

An outline sketch of this species (a poor one, however,) is given on Plate XXVI., fig. 8. Our Cabinet has no specimen; but I am indebted to Mr. Field for liberty to trace this outline from a specimen in his possession, found upon his farm. It differs from the first species only in being more delicate and in the *shortness of its steps*, if I may apply such a term to the successive muscular movements of an annelid.

Nature of the Animals of this Genus.—It is well known that some annelids move forward by pressing down the anterior extremity of their bodies upon the ground and then by a muscular effort bringing up the other parts of the body. One cannot look upon the trackways of the species of Halysichnus without a conviction that these animals advanced in the same manner. I have, therefore, placed these species under the Annelids, although aware that some other animals, and especially the larvæ of insects, move forward in the same manner.

Genus V.—CUNICULARIUS, (a miner.)

Animal constructing a covered pathway along the surface; using bits of the soil to form the arch. Able to move backward as well as forward.

Species 1. Cunicularius retrahens. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{9}{14}$, $\frac{33}{36}$, $\frac{33}{50}$, $\frac{37}{24}$.]

Trackway crooked and branched. Branches terminating abruptly, and sometimes showing an accumulation of mud at the end. Animal able to move backward as well as forward. Impressions made either by the animal or its rough tube, upon the rock above as well as below. Width of the furrow, 0.22 to 0.4 inch.

A rather imperfect outline sketch of one of these trackways is shown on Plate XXVI., fig. 4.

Locality.—Turner's Falls, below the cataract and near the trap. Also at Middletown, Connecticut.

Nature of the Animal.—As mud holes dry up in the summer it is not unusual to find the surface more or less covered with small raised and crooked ridges, not made by an animal merely crowding along just beneath the surface, but by the mud prepared in some way and made rough by being broken into small pieces. Although I have frequently noticed their appearance, and knew that it must have been produced by some worm, I have neglected to ascertain its nature, not supposing that any thing analogous would meet me in my ichnological researches. But if I have not mistaken the character of the Cunicularius retrahens, its trackway is of the same description. It is so peculiar, however, that I have been several times on the point of concluding that the specimens are not of animal but vegetable origin. One of the usual characters by which we distinguish a track from a

vegetable here fails us, viz.: that the track only depresses the surface: whereas a vegetable interposed between the layers will leave an impression also upon the layers above it which have mantled upon it. But if this trackway was formed as I suppose, the covered way, being raised above the surface, would become a cylindrical body interposed between the layers of mud as they were silted in after the animal had constructed its subterranean passage. It is Annelids that build tubes around them in the sand, and cement the walls together; as the Lumbricus marinus, the Sabella, Terebella, &c.; and, therefore, I leave the Cunicularius among the Annelids.

Genus VI. — SPHÆRAPUS, (σφαῖρα, a sphere, and πούς, a foot; the sphere foot.)

Trackway consisting of a furrow, in the bottom of which are two rows of spherical impressions, as if made by tubercles, rather than the feet of the animal.

Species 1. Sphærapus larvalis. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{36}$, $\frac{20}{9}$.]

Width of the trackway, 0.2 inch. Diameter of the small spherical dishes made by the tubercles, which are evidently sessile, 0.08 inch.

Distance between the impressions made by the tubercles 0 to 0.05 inch.

An outline of the trackway of this species is given on Plate XXVIII., fig. 2. On Plate VII., fig. 33, are shown the tracks of a larva of an insect; which I refer to here, because they certainly bear a strong resemblance to the trackway of this fossil species.

Locality.—Turner's Falls, on Mr. Field's farm.

Species 2. Sphærapus magnus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{36}{15}$, $\frac{10}{6}$.]

Width of the trackway, 0.55 inch. Diameter of the small spherical impressions, 0.15 to 0.2 inch, Impressions generally almost in contact, but when the animal changed his course, the outer ones are separated as much as 0.4 inch, either because the impressions are real steps, or the muscles were stretched in changing the course.

An outline of the trackway of this species is given on Plate XXVIII., fig. 3.

Locality. — The hard red shale at Turner's Falls.

Remark. — This species differs from the other chiefly as to size. The tubercular impressions are arranged with a little more regularity in the S. larvalis, than in S. magnus. The former looks more like the larva tracks above referred to than the latter, and hence the name *larvalis.*

Nature of the Animal. — In the autumn of 1857, I found numerous larvæ of an insect beneath the rock maple *(Acer saccharinum,)* and feeding on its leaves, whose tracks, figured on Plate VII., fig. 33, so much resemble the trackway of the species of Sphærapus, that I concluded both must have been produced by the same class of animals. Hence I placed the Sphærapus among the Insects. But if we recur to a principle of paleontology already stated in the early part of this Report, that what are now larva forms typify extinct

adult forms, we ought to look among existing adult forms to find the place of those ancient forms that correspond to existing larva forms. If so, we are led more probably to the Annelids than the insects for the place of the Sphærapans. For some existing Annelids have "tubercles arranged in pairs along the under side of the body, which serve the purposes of feet." (*Roget's Bridgewater Treatise*, Vol. 1, p. 201. Philadelphia. 1836.) I have thought it safest, therefore, to place this genus among the Annelids. Nor should I be surprised if the Cunicularius should be found identified with the Sphærapus. My specimens are defective just in those parts where we should look to settle this question. Should this conjecture turn out to be true, then the Cunicularius should be dropped and the Sphærapus retained.

Opinions of distinguished Zoologists and Anatomists as to some of the Invertebrate Tracks.

I forwarded proof sheets of some of the Plates attached to this Report, especially of the smaller tracks which I have supposed made by invertebrate animals, to several gentlemen, asking their opinion as to their nature so far as they could judge from mere delineations. And though the request might seem hardly reasonable on account of the imperfect idea which the drawings convey of the specimens, I have been gratified with several answers which I deem so important that I venture to add them to my own imperfect views.

Says Professor James D. Dana: "I have given many thoughts to the Plates of the tracks you sent me, but find it impossible to come to a certain conclusion respecting them. The impressions which you have named Hamipes, (Plate 25,) Bifurculapes, (Plates 27, 29, 30,) Lithographus, (Plates 29, 30,) Hexapodichnus, (Plate 29,) Conopsoides, (Plates 29, 30,) may all be the work of Crustacea. The legs of Crustacea end usually in a styliform joint, which would make the straight or curved scratch; and they are numerous so that four or more rows would be natural; they are placed often at different angles to the body; and often there is an anterior pair thrown more directly forward than the others, — the others spreading more rapidly. The breadth of the track-path is so large in several of them that this would throw the weight of probability on the side of the Crustacea. Such tracks, therefore, as the *Hexapodichnus*, *Conopsoides*, and the *Bifurculapes* may have been made by Macroural species, (shrimp-like,) or some Anomoural. Tracks like those of Lithographus I should rather refer to the Isopod Crustaceans (sow-bug group.) The Isopods throw their legs outward or obliquely backward, excepting the anterior pair, which are sometimes chelate and thrown directly forward; moreover the legs in many species have a hooked or uncinate form like the tracks of the Lithographus. In the legs spreading outward and backward they differ from the Macrourans in which they extend usually obliquely forward."

"As to the other impressions I could not give any suggestions of value."

Says Professor Joseph Leidy: "Observation should precede speculation, and in the subject upon which you wrote to me I can only advance the latter. Figs. 4, Plate XXIX., 3, 4, 5, 6, 7, 9, XXV., 1, 2, 3, 4, 6, 7, 9, XXVI., look to me like fucoid impressions. May not 4 of XXIX. have been a delicate rete-like fucus, which has left the impression of its conceptacles? The figures of Plate XXX. appear to me to be the tracks made by small

crustaceans; and this is perhaps the case, also, with the marks of Plate XXVII.; 2, 3, 6, 7, of Plate XXIX., and 1, 2, 8 of Plate XXV. Similar appearances to these which I think are crustacean tracks, I have seen on the sea-shore, made by both insects and crabs, so far as I can recollect. Such observations ought to be made on the ocean beach, and casts taken in plaster, which could be readily done."

On his return from Florida, Professor Agassiz wrote me as follows, respecting some of the tracks which I have figured; though I am unable to say to which of the Plates he refers: doubtless, however, to some of those which I have grouped under crustacea, myriapods and insects.

"While in that region (Florida) I have made many important observations respecting the footmarks, and satisfied myself that I was correct in referring all the double tracks, as well as those with many rows, to the class of crustacea. Indeed, some of these animals make very different tracks according to their various gaits; and you would no doubt be surprised in tracing the Ocypode arenaria, to perceive how close some of its tracks are to those of the sandstone of the Connecticut Valley — the same species making several of your genera. It would be worth your while to go south for that special purpose."

Tabulur View of the Lithichnozoa.

At the end of this Report, immediately before the Glossary and Index, I have placed a Tabular View of the characters of the Lithichnozoa, prepared by my son, Charles Henry Hitchcock, Curator of the College Cabinets. And as he has spent much time in arranging and labelling the Ichnological Cabinet, he alone of all men is able to distinguish and point out the characters of the different species described in this Report. I mention this, because when I am gone, it may be convenient to have some one at hand who can explain my views, should he survive me.

Other Phenomena connected with, or illustrating the Fossil Footmarks.

1. *Impressions and Casts of Rain Drops.*

The same surface over which the animals of sandstone days walked, often shows numerous minute hemispherical impressions most clearly referrible to rain: for rain now produces exactly the same markings upon mud. If the surface thus impressed were sun dried, so that when water brought in a layer of mud over the spot, it did not wash away the impressions, and the whole was ultimately converted into stone, on splitting these layers apart, on the lower one we should find depressions, and on the under side of the upper one, protuberances or casts of rain drops. Such we do find: the phenomena being parallel to those of the tracks, excepting that the rain drops do not show themselves on successive layers, except as the result of successive showers; for a drop of rain could scarcely at all depress the layers of mud as an animal would do. If the rain drop, however, struck the surface obliquely, it would produce an elongated impression, and such moulds and casts we sometimes find. These show us of course the direction of the wind at the time of the shower; while the size and number of the drops give us an idea of the amount of rain

These specimens, then, furnish us with a rain gauge and an anemometer for those ancient times, and they show us that the same laws regulated storms then as now.

Having given in my Final Report on the Geology of Massachusetts, a sketch of a good specimen of rain drops on stone of the natural size, I have in this Report attempted only to show a few varieties of the impressions. The subject deserves a fuller series of illustrations than I could give here, without reducing too much the number of Plates illustrating the footmarks, or swelling the whole number to an unreasonable extent. The specimens in the Cabinet (Nos. $\frac{22}{3}$, $\frac{22}{4}$, $\frac{22}{6}$, $\frac{22}{8}$, $\frac{22}{9}$, $\frac{22}{10}$, $\frac{22}{16}$, $\frac{22}{17}$, $\frac{22}{19}$, $\frac{22}{20}$, $\frac{22}{5}$, $\frac{23}{1}$, $\frac{23}{2}$, $\frac{23}{3}$, $\frac{23}{4}$, $\frac{23}{6}$, $\frac{23}{11}$, $\frac{39}{3}$, $\frac{39}{25}$ to $\frac{39}{32}$, $\frac{39}{34}$, $\frac{39}{36}$ to $\frac{39}{59}$, $\frac{39}{61}$ to $\frac{39}{65}$, also on clay $\frac{40}{17}$, $\frac{40}{19}$,) show an extensive variety; a few of which of course much less than the originals, are shown on the following Plates, copied from ambrotype sketches.

Plate LVI., fig. 5. Rain Drops.
fig. 6. Rain Drops.
fig. 7. Rain Drops and Ripple Marks: the former in the depressions only between the ridges. This is an unique variety.
fig. 8. Rain Drops.

From some experiments made by me, of throwing water into the air and letting it come down in drops upon a plastic surface, I became satisfied that the most perfect specimens of fossil rain drops must have been made by a slight shower, and not large rain drops. For where the rain falls thick and fast, and especially in large drops, it soon effaces the marks of separate drops, and produces irregular cavities with tortuous ridges, as shown on Plate LVI., fig. 5. The finest examples of rain drops I have seen on mud were produced by the few scattered drops that fell after the principal shower had passed over, and prepared the mud to be finely impressed.

The same surface impressed by rain drops, not unfrequently shows footmarks. If the latter were made subsequently to the former, they would partially or wholly obliterate the rain drops. That the obliteration is often only partial, we learn from specimens on clay, of which Plate XXXII., fig. 1, is a good example; for beneath the boy's footmark, although obviously impressed after the shower, the rain drops are quite distinct. The degree of obliteration would of course depend upon the depth of the footmark and the plasticity of the mud.

The occurrence of rain drops on the same surface with footmarks, is an important fact in our reasoning as to the latter. For it shows us that the surface impressed by the animal, was generally above the water when the tracks were made, and not beneath, as some would suppose. It does not follow, however, that this was always the case. For in some instances my own conviction is, that the tracks were formed beneath the water, as in the case of the Isocampe strata, where not only are the rain drops absent, but the surface has a certain rough and uneven appearance, as we see on mud beneath the waters, and not that smooth and even surface which results from the subsidence of mud rendered plastic by water, which has subsequently more or less drained off.

Gas Pustules.

The layers of clay found in the banks of existing rivers are sometimes coated with a film of argillaceous and organic matter, which has so much tenacity that it may be raised in a bladder by gas collected beneath, which for a considerable time it will prevent from escaping. And either atmospheric air, or some other gas does sometimes collect beneath the surface, and raise vesicles or pustules, which resemble rain drops in relief. When the gas at length escapes, they collapse, yet usually leave a circular trace, which is easily mistaken for rain drops, although not depressed below the surface. Indeed, not long since, some geologists undertook to account for all the supposed rain drops by these pustules. But if they had carefully examined all the phases of the phenomena, they would have seen the difference between the rain drop and the pustule. Plate LV., fig. 2, has on the original some of these gas pustules, although not easily shown upon a drawing.

Ripple Marks.

These are parallel, sometimes tortuous ridges of sand or mud, with intervening hollows, produced by small waves of wind or water, and resembling those of the latter. Wind will not form them in mud, but in sand only; yet water will do it in mud and sand.

Ripple marks are very frequently seen on the surface over which animals walked, although in but few cases have I attempted to exhibit the ripple marks on the sketches of the slabs in the Cabinet. Plate XLIII., figs. 3, 4 and 5, however, show the ripple marks. The tracks on these slabs are quite small, yet very perfect; and I hence infer that they were made subsequent to the ripple mark. Such I believe is always the case; for the process of forming the latter would obliterate the former. But from the ripple marks we learn the important fact, that the surface on which the animals trod, was a little time previously beneath the waters, and that the animals trod upon it before it had been above the waters long enough to get hardened, or to have the ripple marks effaced. Yet subsequently, and with no great interval of time, the spot must have been again beneath the water, in order to bring over it new layers of mud to be converted into rocks. That the interval was short, appears from the perfection of the tracks, which, if long exposed to atmospheric influences, must have been wholly or partially erased.

These facts look more as if the surface trod over by these ancient animals, was the shore of the ocean exposed to the action of tides, than the shores of rivers or lakes, where the water rises and falls only at long and uncertain intervals. The daily rise and fall of the waters would be much more likely to preserve the tracks and rain drops, than a long interval. The only difficulty would be, to make the surface in a few hours hard enough to retain the impressions, while the flood tide should bring in and spread a new deposit of mud. But if a tropical sun were shining upon it, and perhaps, too, an unusual degree of heat were propagated upward from subjacent partially cooled trap, or volcanic grit, this might be done. And that a tropical climate prevailed in this Valley during sandstone days, the tropical plants and animals found in the rock abundantly testify.

Once I could hardly have been made to believe that there was any danger of confounding fossil footmarks with ripple marks; but since I have attempted to work out the genus Ptilichnus as the tracks of fishes, this very question has occasioned me much perplexity, and I am still in doubt whether the species P. pectinatus will not prove to be delicate ripple marks; for certainly the most delicate of these may look much like the impressions made by the fins of fishes. Indeed, I have often been made to feel in these investigations, that objects and operations in nature whose typical forms differ *toto cœlo*, as it were, become in certain abnormal conditions apparently identical. The tyro in philosophy is hence led to doubt whether we can place dependence upon any of the distinctions in nature upon which naturalists rely. But a larger experience brings him off from so superficial a view. It is easy for a man, who has only a slight acquaintance with fossil footmarks, to persuade himself that *ichnolithology* has nothing better than conjecture to rest upon; but a few weeks or even days in the quarries and the cabinets, will show him that this branch of paleontology has as real a basis as any other.

Septaria.

Portions of the material out of which rocks are formed, as they dry, separate into numerous pieces, forming cracks, and when these are subsequently filled by calcareous matter, they are called Septaria, or Turtle Stones. They assume all manner of shapes, and formerly were supposed to be mistaken for tracks, or rather they were regarded as affording a sufficient explanation of what were called tracks. And although that opinion has long since been abandoned, I notice the septaria here, because it is merely possible that some of them might be mistaken for tracks. They are not abundant in this Valley, and are generally small. The only place where I have seen tracks associated with them, is at the quarries in Chicopee, and at Chicopee Falls. But the most stupid observer could not confound the two things at these localities.

Sun Cracks and Mud Veins.

If a muddy and especially a clayey surface be long exposed without rain to a hot sun, it becomes filled with cracks, which generally run in such directions as to form polygonal masses. The cracks are often quite deep, and if afterwards mud is brought over the spot by water, it falls into these fissures, so that when the whole is converted into rocks and split open, we shall have the surface covered with mud veins, which, though they meet and apparently intersect, never cut off one another, but coalesce at the crossings.

These mud veins are very common in the shale of this valley, and to unpracticed eyes are quite perplexing. The most remarkable locality that I have ever seen is at the Portland quarries, where sometimes the surface looks like mosaic, or rather like a pavement of polygonal masses, with mortar between the pieces. Sometimes the edges of the pieces are finely rounded, in some way to me inexplicable. Two examples of this kind are represented from ambrotype sketches, on Plate LVI., figs. 1 and 2, from Portland. These so mimic huge letters, that they are labelled in the Cabinet (Nos. $\frac{26}{2}$ and $\frac{26}{3}$,)

"Nature's Hieroglyphics." Fig. 3, shows a somewhat analogous example from Turner's Falls, though here the surface seems to have been considerably modified by water (No. $\frac{26}{1}$). Fig. 4 represents a similar case from No. $\frac{39}{66}$.

These sun cracks often, probably always, were produced after the passage of the animals that made the tracks: I say always, for after desication the surface would become so hard that animals in general would make no impression. The cracks very often cross the tracks, or more frequently proceed outward from the toes, giving an enormous apparent extension to the toes. But a practiced observer can easily distinguish between the track and the veins. They sometimes distort it somewhat, and in one instance at least produce such an anomalous appearance that I have signalized it in the name, *(Arachnichnus dehiscens.)* In general I have not attempted to delineate those veins upon the Plates. On Plate XXXIX., fig. 1, which is full of them, they are shown indistinctly, and in Plate LX., fig. 1, more obviously.

Fucoids and other Fossil Plants.

The former of these, having sometimes a bifid and sometimes a trifid appearance, were supposed in the earlier days of ichnology, when I had to contend with prejudice as well as with reasonable doubts, to account for all the phenomena of the so-called fossil footmarks. A visit to the quarries and the cabinets showed the entire inadequacy of this explanation. Nevertheless, in the progress of these investigations it is curious to observe how the fucoids and the tracks are brought into close proximity and resemblance, in a quarter not dreamt of by the original authors of this hypothesis. I refer to the annelid tracks. Some of these do so closely resemble certain ribbon-like fucoids, or sea-weeds, that I have found it difficult to distinguish between them. The same is true of certain insect tracks, of which I have given an example under the genus Lithographus, and on Plate XXIX., fig. 5.

Some other plants have been found in this sandstone, which easily might be, and in fact have been, mistaken for tracks. Perhaps the most singular of these is one found ten feet long, by Mr. Field, on his farm at Turner's Falls. Professor Emmons, in his recent work on American Geology, has figured a branch of it as a track. I cannot agree with him in opinion; but of the nature of the plant I shall offer no conjecture, not having studied it, nor attempt to describe it, as that would occupy too much space, and require several plates. I refer to it as an example where we are liable to confound things quite dissimilar in their nature, and in order also to put those who come after me, upon the *qui vive* in their researches.

Tracks of recent Animals and Rain Drops upon Clay and Mud.

In 1841 Dr. Buckland described the tracks of deer and oxen on the mud beneath the peat in Pembrokeshire, England, which must have been made centuries earlier. More recently tracks of wading birds and rain drops have been described by Sir Charles Lyell and others, on the clay in Nova Scotia. These are very perfect. In 1855, my son Charles H. Hitchcock described, in the American Journal of Science, (Vol. XIX., New Series, p. 391,) the tracks of no less than thirteeen species of animals, with rain drops and air vesicles, or

gas pustules. The animals are man, the dog, the crow, the snipe, the frog, some molluscs and annelids, and some unknown species. As the specimens have been presented to the Ichnological Cabinet, I have had ambrotypes or outlines taken of the most interesting, which are shown on the Plates accompanying this Report.

Plate XXXI., fig. 2, shows a row of snipe's tracks and rain drops, all of the natural size, on clay.

Plate XXXII., fig. 1, gives a boy's footmark with that of a bird, probably a crow, and rain drops, of the natural size. The delicate striæ that cross the human foot are perfectly preserved on this specimen, as are the papillæ on the bird's foot; and they show finely how by this character alone, without reference to the form, the tracks of different animals may be distinguished. And they prove, moreover, that such delicate markings might be preserved, and become hardened into rock. I regret, however, that by a slight mistake this human foot is considerably distorted, and the striæ are not fine enough.

Fig. 2 of the same Plate, shows the tracks of a frog, with those of a bird.

Plate LIV., fig. 1, exhibits the tracks of a snipe taken from an ambrotype sketch from No. $\frac{40}{34}$. The animal seems to have stopped at a certain point and changed his course.

Fig. 2 shows tracks of the same in a line, from No. $\frac{40}{44}$.

On fig. 3 we have the tracks of a very small bird, I know not what, and of a frog, from No. $\frac{40}{48}$.

Fig. 4 presents us with two tracks of a crow, as he stood still.

Plate LV., fig. 2, shows two rows of the tracks of a very small animal, probably a quadruped, but unknown to me, from No. $\frac{40}{30}$. Here, also, we have several examples of gas pustules. I am not sure that I have ever found any of these upon the sandstone, though several appearances there remain yet unexplained.

Fig. 1 of the same Plate is a sketch of the natural size, of the track of a South American Ostrich, from a plaster mould (No. $\frac{40}{28}$) presented me by Professor Jeffries Wyman. It will be seen by this drawing, that though the track greatly resembles in its general appearance that of the smaller species of Brontozoum, and shows protuberances, they do not correspond well to the number of phalanges. It is remarkable that the fossil tracks are so uniform and definite in this respect.

On Fig. 3 of the same Plate, may be seen the tracks and tail trace of a small salamander, caught by Roswell Field, and made to leave these impressions on mud as a condition of liberation. Mr. Field has presented the specimen (No. $\frac{40}{16}$) to the Ichnological Cabinet, and there it illustrates and confirms the views that have been presented in the preceding detailed descriptions as to the fossil tail traces, which exactly resemble this recent one.

Fig. 4 of the same Plate shows the trail of a small Annelid, with exceedingly delicate impressions on the sides, of the setæ, or hairs, of the animal; so small are they, that it is difficult to represent them on the drawing. This case shows us what sort of a trail these small worms (possibly a Myriapod) leave upon the mud, and how traces even more delicate than the feet of insects, may be made and preserved. This trail is on clay from Hadley, (No. $\frac{40}{40}$.)

We have, then, in these recent tracks on clay, an almost exact counterpart of all the phenomena of fossil footmarks, and the manner in which they were formed. Here we have formed and preserved under our immediate inspection, the tracks of some thirteen species of animals, from the size of man's foot, down to those of almost microscopic littleness; the smallest and most delicate traces being preserved with a perfection that seems beforehand hardly possible. The season when they were formed was a hot and dry one, and the spot an area of some acres of clay, denuded of soil, on the banks of Connecticut River. Here every rain storm or shower would leave pools of water, around and through which, various animals walked in search of food. Afterwards the water was dried up, and the clay so hardened that it could be split up and transferred to the Cabinet. This was done several times in the course of the season, and in other years; I know not how any one can escape the conclusion that the fossil footmarks and rain drops were formed in a similar manner. Indeed, I have always found these tracks on mud and clay to be the most effectual argument I could use to convince those who were skeptical as to tracks; and if they withstood this, I have regarded them as hopelessly unbelieving.

It will be seen that this modern ichnology presents us with one interesting addition to the ancient. We have here the tracks of man, and the conclusion is certainly fair, that had he existed when the other animals left their footmarks on stone, his would be found among them. This conclusion is not, indeed, new; but in accordance with the whole testimony of geology, which proclaims man to be among the latest of the animals that have appeared upon the globe.

Results and Conclusions from the preceding Descriptions of the Footmarks.

Some of the conclusions to which almost every mind comes at once on a review of the facts which have been detailed, are almost too obvious to need a formal statement. But it may be desirable.

1. These tracks were made while yet the rocks containing them were in a plastic state. In fact most of them must have been in the most favorable state in which mud can be, for receiving and retaining impressions. The subsequent consolidation of those materials may have been accomplished partly by heat and partly by chemical agency. The length of time occupied in this work is of no consequence; since, after the tracks were covered by mud, they would retain their form uninjured an indefinite length of time.

2. The tracks were made on the shores of an estuary, or lake, or river, where animals resorted for food, as they now do.

The organic remains in this sandstone make it probable that it was not a strictly marine deposit; since, with the exception of what have been supposed to be fucoids, marine relics are wanting, with the exception of one or two species of shells. Yet, as already shown, the occurrence of tides along the shores, is rendered probable. I rather presume that the valley was then an estuary, almost wholly cut off from the ocean, and perhaps the mouth of a large river, the Connecticut of a former continent. This was traversed and dotted by islands, and the curvature of the trap ranges produced several

sheltered coves, where animals would find warm and pleasant abodes; as around Turner's Falls, on the south-east side of Holyoke and Tom, and at Middletown in Connecticut. The space traversed by the animals, was generally only a few feet wide, and hence the tracks are so numerous, as the Plates will show. I know, indeed, of some exceptions, where the animals seem to have roamed over a broad space, as at the east foot of Mount Tom, and in Portland and Middletown; but the sheltered spots, then coves, seem to have been their favorite haunts. Hence it is that we find so many species huddled together.

3. The probability is that the climate, during the sandstone period, was tropical, with perhaps an alternation of wet and dry seasons. The surface, as the gigantic sun cracks indicate, must often have been subject to powerful heat; and perhaps it would require a greater and longer continued heat than now occurs, to harden the tracks, so that the returning waters should not wash them away before they were covered by a deposit of mud. The great size of the animals, also, indicates a tropical habitat, if we judge from existing nature. Moreover, the huge trunks of trees dug out of the Portland quarries, although their exact nature has not yet been determined, have a decidedly tropical aspect. And still more certainly tropical is the radiated Clathropteris of East Hampton, and Turner's Falls.

I am aware that Dr. JOSEPH BARRATT, of Middletown, who has paid great attention to this subject for more than twenty years, maintains that he has discovered *frost marks* in the sandstone. He has kindly shown me his specimens, which may, indeed, have had such an origin. But they do not seem to me to require any other agency than water, and perhaps Annelids, for their production.

4. The consolidation of the tracks may have been hastened by the trap rock not yet cooled, when they were formed, lying often at no great depth beneath the thoroughfares which the animals trod.

This conclusion is not absolutely certain: but if the trap was introduced in the manner and at the times suggested in the preliminary part of my Report, it may have retained heat enough, up to the time of the deposition of most of the footmark layers, to hasten the work of their consolidation. If so, it may help explain the singular fact, that the sandstone of this valley has retained more footmarks than all other deposits on the globe hitherto described. And yet, one would suppose that similar circumstances as to the trap and sandstone, would have existed in other places.

5. Were this the proper place for indulging in curious speculation, and deducing moral conclusions from physical facts, a wide field opens before us. But I will indulge only in a single suggestion. We see in the preceding details, how the slightest action of ours, even the most unnoticed decisions of our wills, may make an impression on the globe, which will endure, and may be read, as long as the earth exists. To illustrate this thought, let me recur to Plate XLV., fig. 1, where Tridentipes gracilior is seen to have marked out a portion of an ellipse by its track; or to Plate XXX., fig. 3, where an insect, or crustacean, the Bifurculapes laqueatus, is seen to have marked out a circle by its track. Now this change in the animal's course must have required the use, and the increased or diminished action, of certain muscles in its legs. We have, then, in these curved tracks,

certain evidence of the peculiar action of the Adductor, or Sartorian, or Gastrocnemian muscle, or of all of them together, in the leg of a small bird; nay, of a small insect; perhaps ten, perhaps fifty, perhaps a hundred thousand years ago! Still further, that muscular movement implies a previous act of the animal's will, and that implies, as we now know, an electric current inward along the sensor nerve, and outward along the motor nerve. With the register before us of the decision of an insect's will, made fifty thousand years ago, and the corresponding movement in the muscles of its legs, who will dare to say that any action of ours, or any operation of the human mind, will certainly be so lost that it may not reappear in all its freshness ten thousand ages hence!

6. Let us now now take a synoptical view of the species of animals that once lived in the Connecticut Valley as made known by their tracks. As already stated again and again in describing them, I expect that future discoveries will strike out some of these species: but my prediction is, that they will bring a still larger number of new ones to light.

Number of Localities of Tracks in the Valley thus far discovered,	38
Length of the Sandstone Belt containing Tracks,	90 miles.
Width of the Sandstone Belt containing Tracks,	2 or 3 miles.
Whole number of Species in the Valley described above,	119
Number of Bipeds,	31
Number of Quadrupeds,	55
With more than four feet,	18
Without proper feet,	12
With an uncertain number,	3
Marsupialoid Animals,	5
Thick-toed Birds,	14
Narrow-toed Birds,	17
Ornithoid Lizards or Batrachians,	10
Lizards,	17
Batrachians, the frog and salamander family,	11
Chelonians, the Tortoise family,	8
Fishes,	4
Crustaceans, Myriapods and Insects,	18
Annelids, the naked worms,	8
Of uncertain place,	6

In the above enumeration I have placed Gigantitherium, Hyphepus, Polemarchus, Palamepus and Typopus, among the quadrupeds; although as yet no fore feet have been discovered. But since those of Apatichnus and Otozoum have come to light, I am prepared to find them on all those species, whose other characters ally them to quadrupeds; and I think it safer to judge by the general principles of comparative anatomy and zoology of an animal's character, than to infer its deficiency in any organs because we have not found them.

I am aware that some intelligent and perhaps even scientific men will look upon the preceding results as little better than conjectural. They believe that we are very liable

to be deceived as to the true character of the tracks, and even if that is ascertained, they doubt whether it is sufficient to give us the probable nature of the animal.

In the preceding details I have so often admitted the difficulties and uncertainties of ichnology, that I need not repeat the statement. But because this science often leaves us in doubt, is it philosophical to infer that it is always at fault? Should we conclude that zoology and comparative anatomy are wanting in all settled principles, because it cost many years of labor and acute reasoning before the true place of the Ornithorhynchus, the Siren, the Pterodactyle, Ichthyosaurus, Zeuglodon, and many other animals, was determined? No one thinks of giving up these sciences on account of such facts; for the great difficulty in these cases was, that the animals named had great peculiarities of structure, and it was not easy to say which predominated. All knew that they were new and peculiar; but where characters common to several classes of animals were so strangely blended, it was not easy to locate them. It is the same anomalies of character that perplex us in the footmarks. To be sure we have only the tracks to judge from; but this gives us often an accurate idea of the whole foot. And is there not as much of corelation between the foot and other parts of the body, as between any other organ and the whole? Indeed, has not the foot been regarded as a peculiarly characteristic part? So, as we have seen, was it regarded by the father of comparative anatomy. And all my ichnological researches have strengthened my faith in that opinion. That it will be necessary to change the place of some of the species which I have described, I expect. If I could have had access to the large collections of comparative anatomy and zoology in Europe, I might have avoided some errors. Living in the midst of a region which has become classic ground for ichnology, I have done what I could in laying the foundations, and in gathering a store-house of materials. Let others, with better light to guide them, carry up and complete the structure.

A MORE POPULAR DESCRIPTION OF THE FOOTMARK ANIMALS.

Having gone through with the strictly scientific details of the subject, it seems to me desirable to present, if possible, a more popular account of the most remarkable of the races that formerly trod the shores of the Connecticut; for it is not probable that many will have the time or the patience to go through with all the detailed descriptions which have been given. Here of course I cannot avoid all repetition.

In order to appreciate these views, we ought to bear in mind that the records of paleontology lead us to presume that among the animals of oolitic days, to which we now refer our sandstone, we shall find some of very anomalous character. The Ichthyosaurus, Plesiosaurus, Pterodactyle, Iguanodon, and other huge Saurian reptiles lived then, and from their strangely anomalous characters, as described on a previous page, we ought to presume that the congeneric races on this continent would not be less peculiar. And so we find them, judging from their tracks.

In reviewing these extinct animals, I shall follow the order in which they have been described.

At the head of the list stand five species, which I have denominated Marsupialoid,

that is, animals appearing like Marsupials. These, it is well known, belong to the order Mammalia of zoologists; and although the lowest in organization of that family, yet they are regarded as higher than birds and reptiles. They seem to have been the earliest of the mammiferous class—as we should expect from their low grade of organization they would be—that appeared on the globe; five species at least having been found in the European oolite. It is with much hesitation that I refer five species more from their tracks, not to marsupials proper, but to *Marsupaloids.* Yet I am sometimes inclined to believe that a large part of the fifty-four quadrupeds which I have described, belong to this family; for very many of them have unequal feet, and this is a common character among living marsupials. It is, also, a curious fact, that almost all the mammalia in Australasia are marsupial, and it seems as if we are carried back by the Fauna of that part of the world to sandstone days. But I venture at present to describe as marsupialoid only a few species. Nor can these be looked upon simply as marsupialoid; for I judge that they must have partaken of the characters of other tribes.

I have called the first genus a *Cunoid Marsupialoid;* that is, an animal partaking somewhat of the character of the dog family, as well as the marsupial. (Plate LX., figs. 2, 3 and 4.) Its tracks, which I have found only in the Portland quarries, considerably resemble that of the dog, though no claws are seen. The fore feet of that animal show on mud, only four rounded impressions, and one behind for the pad of the heel, not much unlike the fossil track. I think, however, that the fore and hind feet in the latter, are somewhat unequal, and as the presumption is in favor of the animal's having been a marsupial, I place it there with the modifying prefix, *Cunoid.* It may have been a mammifer higher on the scale than a marsupial, and when I first saw its tracks, I could not avoid such a conclusion; they looked so much like those of a dog, and the quarries appear to me to be situated very high in the formation.

The second variety of Marsupialoid animal I have denominated *Ornithoid;* that is, looking like a bird; because the toes of its hind foot so closely resemble those of a thick-toed bird. It embraces the Anomœpus major and minor; and the elucidation of the characters of their tracks has cost more study than perhaps any other species that has been described. The outlines of the feet, as we now understand them, are given on Plates VIII. and IX. Before the discovery by Mr. Field of a posterior extremity, of the nature of a tail, the animal seemed like an enormous frog, in spite of its trifid hind feet. But the idea of a frog with a tail, could not be entertained; and I turned next to the Marsupials. And here I found that the kangaroo has five toes on its front feet, like the Anomœpus; and though the hind foot has originally the same number, they ere long become consolidated into three. Then the long heel of the hind feet agrees with that of the kangaroo. The stout tail of this animal, also, is used as a basis of support when it rests upon its hind feet: and so in the fossil species, its caudal appendage seems to have been a stout, blunt projection, that might have served as one of the legs of a tripod, for sustaining the animal when resting upon its haunches. The indentation made by the end of the tail at successive intervals, looks as if the animal moved by leaps, and my

impression is that it might thus move; but I have given reasons for supposing that it might usually advance by a movement partaking of the nature both of a leap and a step.

So much for the marsupaloid character. But its hind feet, especially when separated from the heel, as we often see it in the tracks, can hardly be distinguished from those of a bird; with which, for a time, they were confounded. I am not certain as to the number of phalanges in the outer toe, but incline to the opinion that they correspond to those of birds. Certainly they do in the two inner toes; but in their distinctness on the tracks, they agree with what I suppose to have been thick-toed birds, and not with any living marsupial.

In this species, then, it seems to me we have an animal combining characters now found in marsupials and birds. The marsupial predominates, since no analogies will justify us in so departing from the existing types of animals as to admit a fossil four-footed bird.

I have placed the two species of Anisopus among the Marsupaloids rather than among the Batrachians, chiefly on account of their manner of walking; which was almost in a straight line, the tracks deviating but slightly to the right and the left. The rows of these tracks, shown on Plates XXXV., fig. 5, and XXXVI., fig. 1, copied from slabs in the cabinets, will demonstrate this statement. Now it is certain that no existing Batrachian or Lacertilian could walk in this manner, but with feet much farther to the right and left of the median line. Mammiferous animals with long legs, however, do often move almost on a right line. I have presumed, therefore, that these animals might belong to that class; and I have referred them to Marsupialoids, because they have unequal feet. I have called them *Loricoid*, or Crocodilian; that is, appearing like the scaly or crocodile tribe of lizards, because they have five toes before and four behind, and some of the toes, the outer one certainly, in Anisopus gracilis, are wanting in claws. They are diminutive, indeed, compared to the huge crocodiles and alligators of modern times; yet they may have been formed on the same general type. It must be confessed, however, that the tracks have a Batrachian aspect, and perhaps should be called *Batrachoid;* yet living Batrachians have four toes in front and five behind; whereas in the Anisopus, this order is reversed.

This rectilinear movement of many of the track-discovered four-footed animals, has, I apprehend, received too little attention; for it gives a clear indication of the form and character of the animal. It is certain that such animals must have had long legs and narrow bodies, such as are now found almost exclusively among the mammifera. Hence, as intimated in another place, I cannot but sympathize in the opinion of Duncan, Bronn, Wieggman, and Humboldt, as to the character of the Cheirotherium of Europe. They refer it to the Marsupials; yet others equally eminent, as Linck, Munster, Owen, and Kaup, believe it to have been a Batrachian. But if, as I suppose, its tracks succeed one another almost in a right line, it could not have been a Batrachian of the modern type.

The next Group of the Connecticut Valley oolitic fauna, have left tracks more perfect and better characterized than any others. They were three-toed and thick-toed animals,

with all the phalanges of the toes and the claws at the end often quite perfectly exhibited, and sometimes even the papillæ and striæ of the skin. (See Plates X. to XIII.)

First comes that huge giant, Brontozoum giganteum, with a foot 18 inches long, and embracing an area 13 inches square within its outlines. Its stride was from 30 to 60 inches, and its legs were so long that it went forward nearly on a straight line. The great resemblance between the general character of the foot and those of the Cassowary and Rhea, or South American Ostrich, and especially the number of the phalanges in the toes, corresponding exactly to those of birds, make it extremely probable that this was the great *courser* of sandstone days.[16] In my Final Report on the Geology of Massachusetts, I have gone into a calculation to show the probable height and weight of such a bird. I will not here repeat the details. (See Report, p. 522.) But the result was that the animal must have been 12 feet high, and have weighed from 400 to 800 pounds. The ostrich, the largest living bird, stands between 7 and 8 feet in height, and weighs sometimes 100 pounds, and the length of its step in walking is 26 inches.[17] The great extinct birds of New Zealand and Madagascar must have been nearly or quite as large as the Brontozoum. The recently discovered fossil bird *Gastornis Parisiensis*, in the tertiary rocks near Paris, was "at least as large as an ostrich."[18]

Yet it appears that these enormous birds passed over the surface in flocks, as their rows of tracks, near the railroad in the south-east part of Northampton, show. They were doubtless wingless (apterous) birds, like the ostrich, dinornis, and æpyornis. But how amazed should we be to meet flocks of such birds now. Slightly to change the saying of the Latin poet, however, *tempora mutantur, et mutandum est avibus;* (the times have changed, and the birds must change with them.)

But these lords of the soil were not without subjects, who yet were so much like them as doubtless to be "kith and kin." Not less than thirteen species of this character have left distinct footmarks. They were all large birds, some of them, the Brontozoum minusculum, tuberatum, exsertum, and validum, almost able probably to compete with the B. giganteum; and doubtless inclined, taking men as the standard of comparison, to be rebellious, and sticklers for their rights and dignity. The smallest of them must have been as large as a turkey. They seem to have associated, in search probably of nourishment, on the shore left by the tide, which was doubtless their daily hunting ground.

[16] I speak of these animals as certainly birds, though doubts sometimes cross one's mind on this point: and I am aware that with some distinguished zoologists these doubts are strong. But I follow what seems to me at present the most probable view.

[17] I quote here from the Journal of that extraordinary African traveller, Dr. David Livingstone, who states that "when the ostrich is feeding, his pace is from 20 to 22 inches; when walking, but not feeding, it is 26 inches; and when terrified, it is from eleven and a half to fourteen feet!" He estimates that in such a case his rate of speed is twenty-six miles per hour. (See *Livingstone's Missionary Travels*, p. 172. New York Edition, 1858.) There is nothing in the fossil tracks to indicate a more than ordinary speed; so that we may regard the common step of the ostrich as a little more than half that of the Brontozoum.

The same work gives us the size of the tracks of the wild African elephants, the circumference varying from 48 to 57 inches; consequently the diameter, or length of the foot of the largest, is about 18 inches. Doubtless this is much the largest of the tracks made by living animals, and nearly or quite equals the largest fossil footmarks. (*Same Work*, p. 604.)

[18] Owen. See *Proceedings of the London Geological Society*, p. 204. February 20th, 1856.

How finely a row of these thirteen species would have appeared, standing up side by side; What a temptation to a modern sportsman! What an attraction in an ornithological gallery!

Some of these birds had extremely long legs, and I have arranged them under the genus *Grallator*, which means, one who goes on stilts. The stride of the *Grallator cursorius* (the racer) was 24 inches,—very large for a bird of that size,—and the tracks are placed almost in a right line, and the axis of the foot is coincident with the median line; all which circumstances indicate a long-legged animal.

In the third Group we have seventeen species of what seem to have been three and four-toed, narrow-toed birds. I bring all these species together, in this notice, because they differ chiefly in the presence or absence of a hind toe, and this so seldom made an impression on the mud, that its absence from numerous specimens is no sure sign that it did not exist in the animals, and possibly all the three-toed species may be proved four-toed by future discoveries. I have been able to make two or three of these changes in the present Report; but their names need no change, and the evidence of their *ornithic character* is as strong with four, as with three toes. That evidence is not as strong in respect to this Group as in regard to the second, because we have in the former tracks no phalangeal impressions. Still the analogies lead more strongly towards birds than any other class of animals; and there I leave them at present; not without a suspicion, however, that some of them may turn out to be quadrupedal; which suspicion is excited by the form of the foot. I do not forget, however, that if in those days there were ornithoid marsupials, batrachians and lacertilians, there may have been batrachoid and lacertiloid birds.

The largest species in both these groups, *Argozoum Redfieldianum*, and *Tridentipes ingens*, are worthy to be leaders of their respective tribes, if size and physical power be the ground of distinction among animals, as it is among savages. These species, probably less clumsy than the Brontozoum, might perhaps have been a match for that giant; and the lesser species of this group, might have been drawn up in battle array with those of the second; though, indeed, as they preceded man, and were not, therefore, corrupted by his example, we would rather believe that harmony and mutual deference prevailed among those pre-adamic races. (See Plates XIV. and XV.)

The fourth Group brings before the imagination a series of animals, some of them of gigantic proportions, and combining characters now only found in two or three classes. I call them Ornithoid Lizards or Batrachians, because, while in some respects they seem to be assimilated to birds, in others they approach either lizards or batrachians; for as already observed, it is not easy in many cases to distinguish between the two latter classes. (Plates XVII. and XVIII.)

The most remarkable of the whole Group is the Gigantitherium caudatum. As yet, we have no evidence that it had but two feet, and some presumption that it had no more; for its row of tracks, as may be seen on Plate XLIV., fig. 4, is arranged almost upon a straight line, even more so than those of the Brontozoum giganteum, which it rivals in size. And as we have seen, the tracks of quadrupeds are not apt to be thus disposed.

But if a biped, how strange its appearance must have been! For it had a foot 16 inches long, covering a square foot of surface, and must, therefore, have had a huge body. When I first saw its track, although it had a small fourth toe, I thought it a bird; but when I found soon after, that it had left the distinct trace of a tail, that opinion must be abandoned; for the trace could neither be explained by referring it to the dragging of the feet, nor to the large tail feather of a bird. Yet if a biped, its body must have had somewhat the form of a bird, in order to keep it properly balanced. The tail, although evidently rather stout, was not enough so to help prop up the body. And how very strange must have been the appearance of a lizard, or batrachian, with feet and body like those of a bird, yet dragging a veritable tail!

But even if it should hereafter be discovered that this animal had fore feet, I presume they will be found to be small, and probably might be used only occasionally; for when I see an animal like this and the Otozoum, to be noticed farther on, leaving a regular succession of right and left tracks of the hind feet, nearly in a right line, my conviction is, that they had the power of walking on two legs, or four; and that they usually employed only two. These hind legs, also, must have been quite long to enable the animal to take steps so nearly rectilinear. In short, either with two or four feet, it seems to me that this animal must have been a match for the Gorgons and Chimeras of mythology. Yet the huge footmarks in the Ichnological Cabinet, satisfy every observer that it was no dream of fancy, but a real inhabitant of the Connecticut Valley.

The smaller species of Gigantitherium, has left no impressions of a fourth toe on any specimens,—and we have several very distinct ones,—in our Cabinet. Yet the track exhibits the peculiarities of this genus so distinctly, that for the present I leave it there, in the expectation that the fourth toe will be discovered. This species, though small compared with the G. major, must have been larger than the Cassowary, or Rhea, though less than the African Ostrich. I compare it to birds, because it must have been ornithoid as to the shape of its body.

I should place the Hyphepus Fieldi in the same genus, did not the track show the impression of a web too distinct to be mistaken. This is the ground on which the name is given, Hyphepus (ὑφὴ, a web, and ποῦς, a foot,) meaning a *web foot.* Hyphepus Fieldi means the web-footed animal discovered by Field. Roswell Field, Esq., of Gill, did indeed first bring it to light, as he did the two species of Gigantitherium, and many other species, which I have credited to him in the preceding descriptions. It was on his farm that Dexter Marsh obtained one of the most splendid specimens of footmarks ever found, which is now in the Cabinet of the Boston Society of Natural History, and whose counterpart, somewhat smaller, is in the Appleton Ichnological Cabinet (No. $\frac{13}{4}$). Since Mr. Marsh's death, Mr. Field has been indefatigable in getting out specimens. He has shown great skill and tact in the business, and has doubtless brought to light more species than any other man. His farm, and the region contiguous, contain many a rich paleontological mine, not merely of tracks, but also of fishes and vegetables. It is fortunate that it is owned by one so well qualified to bring to light these hidden treasures, and discriminate between the different species. Valuable as his farm is agriculturally,

we should rejoice to see it blown up from its deepest foundation. And we doubt not that such a *bouleversement* would not only fill the cabinets of the land with rich relics of sandstone days, but also be more profitable pecuniarily than surface cultivation.

The Hyphepus, Otozoum, and Shepardia are the only genera in which the evidence of a palmated foot among the tracks is distinct enough to enter into the descriptions. The marks of the web are, I think, upon the whole the most decided in the first genus. Its tail, also, made a more continuous trail than that of the Gigantitherium, and seems to have been stouter in proportion to the size of the body. Yet the resemblance is rather strong between the Hyphepus and Gigantitherium, and perhaps they ought to be placed in the same genus. The drawings show that we have many long and quite distinct rows of the tracks of Hyphepus, and if it had fore feet it seems very strange that they have not been discovered. If it had none, then we have in this genus another example of a biped ornithoid lizard, or batrachian.

Of the next five genera in this Group, the Corvipes, Apatichnus, and Plesiornis are remarkable as having been almost up to the present time regarded as birds. Their tracks, as most usually exhibited, certainly do bear a very close resemblance to those of birds; and I must believe that they partook largely of the Ornithic type. But if quadrupeds, their lacertilian or batrachian characters must have predominated; for when we come to admit anomalies in ancient animals so great that there might have been quadrupedal birds, we have cut loose from comparative anatomy and zoology as guides in our researches. Yet these animals must have presented as great peculiarities in ancient times, as the ornithorhynchus among living races. The fact that in the tracks of the Typopus the axis of one foot is turned outward many degrees more than the other, seems to me to indicate that the animal's leg had been broken, and without surgical aid joined together again so as to stand awry. (See Plate XLV., fig. 7.)

The fifth Group brings before us a collection of animals, which may be regarded as true four-legged lizards; yet not without peculiarities in some of the species. That one which I have placed first on the list, may not be assigned to the right place; for I have in the Cabinet only the foot represented on Plate XVIII., fig. 1, which I suppose to be a hind foot. Its fore foot has not been discovered. But there has been no opportunity to make such a discovery; since the three distinct specimens in the Cabinet were got out by others, and are but little larger than the track, so that the chances of finding another foot were very small. Yet those we have look so lizard-like, with their long curved slender toes, that I infer the existence of fore feet; or possibly these may be such. But the great size of the heel corresponds better with a hind than a fore foot. I have called the animal a Polemarch, (*Polemarchus gigas,*) which, among the Greeks, meant a leader in war. Such might this lizard have been, if in other respects as well armed as in his foot; a foot 15 inches long, with a heel nearly as large as a horse's hoof, and armed with a stout spur, or lateral toe. A crocodile ten feet long has a foot scarcely ten inches long. (*Cuvier*, *Oss. Foss.*, Tome 5, p. 104.) Can it be that this animal was so much larger than such a crocodile as these numbers imply?

There is another character, besides its great size, that allies this animal to the crocodiles, rather than the common lizards. It has only four toes upon its hind feet, and that is the number with the crocodile; but the common lizards have five before and behind. This track has been found only near the mouth of Chicopee River, and there probably once lived animals allied to Crocodiles or Alligators, of enormous size.

The Triænopus leptodactylus, or narrow-toed Triænopus, Plate XIX., bears some resemblance to the Polemarchus. I formerly supposed there were two species of the former; but I rather presume that the specimens are only the hind and fore feet of one species. The toes are exceedingly slender; one of the heels is rounded, the other quite narrow and long. But I cannot tell which belongs to the fore foot and which to the hind one, though usually the longest heel is connected with the hind feet in the lizard tribe. I have met with this species only at Wethersfield and Turner's Falls. Having only four toes on its hind foot, it is allied to the loricated Saurians, though small compared with existing ones.

The same is true of the Plectropterna tribe of lizards, Plate XVIII., figs. 2 to 5. The great length of the heel on the hind foot is their chief peculiarity. The P. minitans had a foot from 6 to 9 inches long, and yet the animal was probably less than an Iguana.

Plate XLVIII., fig. 10, will convey some idea of the track of an animal of very anomalous character, which I have placed in different Groups at different times, and leave it at length among the lizards, perhaps for no very good reason. The name is Antipus bifidus; the first part meaning that the feet point in opposite directions, the second part meaning that the feet have two branches. They look, in fact, like two large blunt forks, with tines from 7 to 12 inches long, and an inch and a quarter wide, pointing in nearly opposite directions, with traces of a small tail, which appear on one side. I hence infer that these are the tracks of one side of a caudate animal, whose feet, like those of some lizards, (see Plate VI., fig. 12,) point in opposite directions. But what can we make of the bifid foot? They do not appear like toes, being blunt, and each of them as thick as the leg. Nor is there any lizard or allied animal that has only two toes. Upon the whole, we see enough in this track to convince us that it was made by some large lizard-like animal, but not enough to give us its true character.

I have connected with the preceding, a specimen shown on Plate XXXVI., fig. 7, in which little is seen except a heel 14 inches long and 2 inches wide, with a stout tail sweeping to the right and left in a serpentine course, as if the animal took long strides. Whether this heel terminated in a fork, as in the other case, I cannot determine. But the tail and the heel look like those of a gigantic lizard, and this is about all we feel tolerably sure of.

As to the smaller lizards, that trod the same shores with the larger ones that have been named, little can be said. Some of them were very minute, less perhaps than any now found, as the Orthodactylus linearis, whose toes scarcely exceeded a thread in diameter. In but few instances am I certain they had more than four toes; and perhaps, therefore, I ought to place all of them, as I have done with some, among the Batrachians.

But I have been guided in some cases by certain almost indescribable resemblances to the feet of lizards, rather than Batrachians. The fifth toe, if it existed, would rarely make an impression that would remain, and in a few instances we find it; affording a probability that it exists in all.

The sixth Group brings us again into contact with animals that amaze us by their gigantic size and anomalous characters. I have denominated them Batrachians, though some of them show characters that ally them to other families, but not strongly enough to bring them into the fourth Group.

The most remarkable of these animals was the Otozoum Moodii. Plates XXII. and XXIII. The largest individuals had hind feet 20 inches long, with a width varying from 13 to 15 inches, which would make the surface covered by the track more than a square foot; and so wide were the toes and metacarpal and carpal bones, that nearly the whole space was covered. Beneath this foot, also, and extending even beyond its margin, was a web, as I have reason to suppose, which, like a great snow shoe, kept the animal from sinking deep into the mud. And yet its feet did sink at least two inches. To do this, must it not have required an animal almost as heavy as an elephant?

I formerly supposed this animal to be a biped, since I had seen several long rows of its tracks, the right and left foot regularly alternating, but no sign of fore feet. At length, however, these have come to light; in only one instance, indeed, but too distinct to be denied or doubted. It seems that it had two front feet, not more than a third as large as the hind ones, with five toes, I think, turned outward, very much like those of the Anomœpus. It is possible that what I call a hind toe, may be a heel; if so, its fore feet correspond, as to the number of toes, with those of living Batrachians. But if five-toed in front, I am not prepared on that account to exclude it from the Batrachian family; for it had other characters of resemblance. 1. Its toes, except the inner one, which seems to have had a blunt, curved claw, are terminated by pellets, as are those of most frogs and other batrachians. 2. It had a web beneath its hind feet. 3. There is some resemblance between the bones of the feet and those of a frog in an embryo state.

These several facts are shown upon Plates XXII., XXIII., XLVI., figs. 2 and 5, as well as XXXIII., figs. 4 and 5.

For reasons suggested in another connection, I incline to the opinion that such an animal as the Otozoum had the power of walking on two feet or four; and in fact did rarely use the fore feet, save when wishing to bring its head to the ground. Its legs could not have been as long as those of the Gigantitherium, since its step was shorter, and its feet in walking wider apart.

As to the web on its feet, (of the existence of a web I have but few remaining doubts, especially after looking at the specimen from which Plate XLVI., fig. 2, was copied,) it might have had a use analogous to that of the Ornithorhynchus, namely, as a paddle when swimming. If so, it must have been a powerful oar. Judging from a specimen owned by the Wesleyan University, I presume the animal had a tail, also, which sometimes reached the ground.

The Frontispiece to this Report, Plate I., which is a view of the Moody Footmark Quarry, exhibits a row of some ten tracks of the hind foot of the Otozoum, still remaining there, the property of GILBERT A. SMITH, Esq., of South Hadley. To show these tracks in their natural position, was a principal object I had in view in giving this Plate.

Imagine, now, a collection of Otozoums walking or sporting along the muddy shore; animals approaching the elephant in size, yet allied to the frog tribe, or perhaps the Salamanders. At a little distance you can imagine a group of the Gigantitherium family; and still farther on, a group of Brontozoums. Which of these giants would be acknowledged as entitled to the first place, we cannot decide. But should a contest have arisen at any time for the supremacy, and these several leaders should have summoned the numerous lesser tribes around them to their aid, it would require another Milton to describe the scene.

The Palamopus, judging from the only specimen of its tracks yet found, should be placed among the Batrachians; and had we not been contemplating such giants, this animal would appear large; surpassing, as I suppose it did, all living batrachians, in size.

With the exception of the Batrachoides, of which I will speak shortly, the smaller Batrachians under this Group appear to be allied to Salamanders. Cheirotheroides and Shepardia, however, have a more frog-like aspect, the first having pellets upon its toes, and the second a web foot. Some of the species appear to have had peculiarities; but time and space do not allow me to go into details.

But what shall I say of the *Batrachoides nidificans* and *antiquior*, or rather of their *mud nests*, shown on Plate L.? They are not tracks, but simply the cavities formed, according to the suggestions I have made in another part of this Report, by tadpoles. The specimens in that most remarkable locality in South Hadley, are the most beautiful of any thing in the Ichnological Cabinet. I have still many doubts of their true nature; but I do know that some species of existing tadpoles form very analogous cavities in the mud; and if these were not thus produced, I cannot imagine how they were formed, since water, in the form of waves and currents, seems wholly inadequate. But if their origin was organic, one or two important conclusions follow. One is, that during the sandstone period of this Valley, Ranidæ (the frog tribe) existed, very much like those now living; since the fossil mud nests are just about the same size as those of the living tadpole. And what is still more important, the facts would prove the same thing in respect to a period so early as the time of the Niagara Group of New York, which belongs to the lower part of the Upper Silurian; an epoch far earlier than any other traces of batrachians have been discovered. Therefore I have called the New York Batrachoides the antiquior.

At the close of the sixth Group I have added two genera whose place in the zoological series I am unable to settle. The Saltator was quite small, and as I conjecture, moved by leaps. I might with some plausibility conjecture that these animals were insects; for the black cricket, so common in our fields in autumn, which moves by leaps, would leave a

track somewhat similar to that of S. caudatus; and the cricket, moreover, has a similar tail. But I will let these species remain under the *incertæ sedis.*

The Hoplichnus, or hoof-track animal, was a quadruped, whose feet left an impression on the ground like that of a single-hoofed animal, the colt for instance; and I have seen no clear evidence that it had toes. Sir WILLIAM JARDINE, in his Ichnology of Anandale, has figured the tracks of several species of an analogous genus from the Trias of Scotland; and some of them show claws distinctly. His largest species, however, (Chelichnus giganteus,) very much resembles the Hoplichnus equus, except that the rows of the latter's tracks are much wider apart. That singular impression, made about midway between the rows of these tracks, (shown on Plate XXIV., fig. 5,) and which, if I mistake not, is sometimes several inches deep, and quite large at the Portland quarries, is wanting in the Scotch specimens, and so is that trail which seems to have been formed by the same caudal extremity that made the hole. Taking all the facts into consideration, (several of them have come to light only quite recently, and I wish I had more time to look further,) my imagination pictures this animal as a thick-bodied quadruped, with a membrane beneath its feet extending beyond its toes, and with posterior part, or caudal extremity quite blunt, which struck the ground at every step, and only occasionally dragged; which in fact served as a fifth foot. Were it not that the Hoplichnus has four feet, I should suspect it might have been allied to the seal and walrus of the present day, whose posterior part might make an impression similar to the one just described.

The seventh Group introduces us to the Chelonians, or Tortoises. Several of these, as the species of Ancyropus and Helcura, appear to be well-marked, and differ but little from existing tortoises. The Ancyropians have left distinct impressions of their feet, but in the specimens in the Cabinet, not of their carapace, or tail. And, moreover, I cannot find but four toes either on the hind or fore feet, though they are five on living tortoises. The Helcurans have left little else but their trails, not only of the carapace and tail, but sometimes, also, of the feet. Yet the impressions of the feet are so imperfect that I cannot determine the number of the toes, or the form of the foot.

It may to some seem absurd to bring in fishes among the animals that made the fossil footmarks. But it is not generally known that some of these animals not unfrequently come out upon the dry land, and walk with considerable facility many rods, some even climbing trees in search of food. KIRBY mentions one, "perhaps a Loricaria, which has a bony ray before the ventral as well as the pectoral fins, and which creeps on all fours on the bed of the rivers, perhaps even when they are dry. These little quadruped fishes must cut a singular figure upon their four stilts." (*Kirby's Bridgewater Treatise*, p. 265.) It is the Siluroid fishes that are best known for this faculty of locomotion; to some experiments upon which, by Professor J. WYMAN, I have referred in another place. Now it seems to me that the fan-like, or comb-like impressions exhibited by the genus Ptilichnus, might have been made by some such fishes striking their pectoral fins upon the surface, either beneath or above the waters, while the row of dots, usually accompanying such impressions, might have been made by the long rays, which sometimes precede or form a part of the fin. I do not feel entirely assured in this opinion. But as to the fourth species,

the P. hydrodromus, there can hardly be a doubt that the trackway which crosses the ridges of ripple marks, was produced by an animal like a fish, swimming along just above them, whose fins grazed the bottom.

In closing my view of the vertebrate animals, I would refer to a few examples of other remains of these extinct races besides their tracks. It has seemed strange to many, that if such an abundance of animals, and some of them so large, once lived in this Valley, they should not have more frequently left their bones, or coprolites, in the rock. I doubt whether we ought to expect to find these relics often, especially the bones, in connection with the tracks. For had one of the animals fallen and died on such a thoroughfare as the shore where they trod must have been, he would probably soon have been devoured by some of the survivors, who came there for the very purpose of finding a dinner. And then, if not devoured, the returning tide, or the next rise of the waters, would have carried away the relics. We should expect, therefore, to find these remains, if any where, in some other place. And such has been the fact in respect to the only skeletons that have been brought to light. Two only have been found; one at Ketch's Mills, in East Windsor, Connecticut: the other near the "water-shops" of the National Armory in Springfield. The rock is the same in both places; a thick-bedded, coarse-gritted, red sandstone, and by inspecting the section (Plate II.,) which passes through Chicopee, it will be seen that the position of these bones (nearly the same at both localities) is considerably higher in the series of rocks than any of the tracks in that part of the Valley, though not higher than they are found on the Turner's Falls Section. It is probable, however, that though somewhat more recent, these animal are fair representatives of those that made the tracks.

The bones near Ketch's Mills were discovered 18 feet beneath the surface, and were first described by Professor N. Smith, B. Silliman, and John Hall, Esq., in 1818, and have been several times noticed, and once figured by myself. (Final Report, Plates 46 and 49.) Also more recently by Professor Jeffries Wyman, in the American Journal of Science. In my Report of 1835, p. 237, I said that "I suspect these bones belonged to a saurian animal." Professor Wyman, a far better judge than myself, says of one of the vertebræ, "it is a caudal vertebræ of a Saurian reptile, to which it corresponds in the shape of the body, and the transverse processes, and more nearly to those of the crocodiles than any other."—(*American Journal of Science*, vol. 20, N. S., p. 396.)

The Springfield bones were discovered by William Smith, Esq., while engaged in superintending some improvements at the water shops of the United States Armory, which required blasting. He did not discover them till a large part had been taken away by the workmen. General Whitney, superintendent of the armory, very kindly ordered a re-examination of the fragments, and Mr. Smith obligingly presented me with whatever pieces could be found.[19] These I put into the hands of Professor Jeffries Wyman, and just before he started for Surinam in February, 1857, he sent me the following statements in relation to these fossils:—

[19] I was also much aided in this research by Messrs. Preston and Ingersoll, gentlemen connected with the offices of the Armory.

"With regard to the bones, I think that there can be no question that they are those of a reptile. This is shown by the configuration of the head, small trochanter, and a part of the shaft of a thigh bone, as well as by the imperfect caudal vertebræ; these last, however, are deficient in the concavo-convex bodies which are found in all scaly reptiles except the Enaliosaurians. Those from the sandstone are flat, or nearly so, on the ends, as in the Mammalia. The most remarkable feature, however, of the whole collection, is that of *hollowness.* This is carried so far, that but for the indications referred to, they might be referred to birds. Every bone except the vertebræ, and perhaps the small phalanges, is hollow. Nothing of the kind is known in Mammalia. Among reptiles the Pterodactyle had hollow bones, and some of them were referred, by Professor OWEN, to birds; but he subsequently corrected his opinion. I have ascertained that the bones of the Chameleon are quite hollow, as well as the ribs of the Boa and Python, and some other serpents. We do not yet know enough of the internal structure of the bones of reptiles to be able to say how common a thing hollowness is. I am, therefore, improving every opportunity to examine into the subject. While the bones from Springfield are as hollow as those of the Pterodactyle, I do not find that they are those of this animal; there is no positive proof of the long fingers, or of the broad sternum which these flying reptiles possessed. The remnants of the foot indicate that the toes were of disproportionate sizes, there being one large toe associated with three quite small ones; perhaps another existed, but there are no signs of it. The claw of the large toe was very strongly recurved. The terminal phalanx of the other toes is deficient, so that we are uncertain even as to the number of the joints. The existence of the large toe in company with the small ones is in favor of a jumping animal."

"I hope, if no accident happens to prevent, to be in one of the homes of reptile life in the course of the next month, and shall be on the lookout for any thing that will aid in forming an opinion. It is my intention to start on the first of February, or thereabouts, for Surinam, in Dutch Guiana, to remain as long as the climate will allow."

"CAMBRIDGE, January 21, 1857."

We perceive in the above description, proofs of the same sort as the tracks present, of peculiarities in these fossil animals, such as have no parallels in existing nature. And if even the skeleton (though unfortunately we have only a part of it) leaves the comparative anatomist in doubt as to the exact nature of the animal, we need not wonder that the tracks alone often leave us in greater darkness. But the bones and the tracks will doubtless cast mutual light upon each other; and it seems already settled from the bones that large reptiles lived in the Connecticut Valley in sandstone days; and this, also, was one of the most common sort of animals, judging from the tracks.

Dr. BARRATT made a suggestion in conversation, in regard to the fossilification of the bones of these ancient animals, which seems deserving consideration. He supposes that he has found numerous specimens of the petrified bones of huge animals in the quarries around Middletown. But there is no bony matter, or none of consequence, remaining. There seems to have been an entire substitution of sandstone for the organic matter. It is

obvious that where the mere form is all we have to judge from, there is large room for the play of imagination. Yet I confess that one or two specimens, pointed out to me by Dr. BARRATT, seemed so closely to imitate a group of large vertebræ, as to deserve attention. For it is a fact, that nearly all the vegetable organic remains in the Connecticut River sandstone, do not retain any of the original vegetable matter, but seem to be mere casts, formed by the filling up of the moulds once occupied by the plant, with sand and mud, sometimes coarser than the surrounding rock. Witness, for instance, the huge trunks of trees from the Portland quarries in the Geological Cabinet of Amherst College, and the smaller ones from Newark, in New Jersey. Why may not a like mode of fossilization have taken place with bones? At Springfield they are, indeed, entirely changed into carbonate of lime; and at Ketch's Mills, they are preserved, having lost only their animal matter. But in the Yale College Cabinet are specimens from Tolland, in Connecticut, having the exact shape of bones; which I have figured on Plate 46 of my Final Massachusetts Report, (figs. 70, 71, 72, 73,) and which no concretionary agency, which I have seen, can explain, but which seem to me to be casts of bones formed like those of trees in the same rock.

If these suggestions should prove true, they may explain the reason why we find so few of the bones of these ancient animals. For, in the first place, if such is the nature of this sandstone, or such were the circumstances attending its consolidation, that even bones would often entirely disappear and leave only a mould, how seldom would the mould have been so filled that the cast should be recognized as that of a bone: and secondly, since we have not sought for such a kind of petrifaction of bones, perhaps by looking for them at the quarries, they may not unfrequently be found, as Dr. BARRATT supposes he has done.

In the ninth Group I have brought together the three great families of Crustaceans, Myriapods and Insects, because from their tracks I find it in many instances impossible, till more is known of the tracks of similar living animals, to distinguish between them. The two first of the ten genera described cannot be Myriapods or Insects, because too large, and they may have been Crustaceans. I regard them as Crustaceans, chiefly on account of their having didactylous feet, such as many of this class possess. But in respect to the Stratipes latus, I am not quite sure whether the feet were didactylous, or whether a monodactylous hind foot was brought up nearly to the place just vacated by a similar fore foot. The tracks are arranged in two rows of five didactylous tracks, twenty inches apart, and directly opposite to each other on the two sides. The animal must, therefore, have moved forward by placing one or more pairs of feet on the mud, and thus pushing his body ahead. Yet no trace of carapace or tail is left; and I have fancied that it might have been a huge crustacean, swimming just above the bottom, and using his feet upon the mud for oars, though I am about as much inclined to regard it as a marine tortoise. Yet I do not know that a crustacean ever moves in that manner. Whatever the animal was, however, and though the exact form of its foot is uncertain, it has left the most certain evidence of its existence and progression. No other tracks occur upon the same surface, though only two inches lower down, that is, on the other side of the slab, are a multitude of as perfect tracks in relief as any in the Cabinet, such as must have been

made above the waters. (See Plate XXXVIII., fig. 1.) But the latter may have been made while the tide was out, and the former when it was in.

I have placed in this connection under the name of Harpagopus, some didactylous impressions on a flagging stone, which I took out of the sidewalk in Greenwich Street, New York, a few years since, and which was quarried from the Hamilton Group of rocks along Hudson River. These too are didactylous, and though some have doubted their animal origin, I still remain of opinion that they are organic, and I think they may have been crustacean tracks. And since the discovery of such tracks in Canada by Sir William Logan, even in the Potsdam sandstone, the oldest of fossiliferous rocks, we surely can believe such animals to have lived during the Devonian period, to which the Hamilton Group belongs. A species making a somewhat similar impression on the Connecticut River sandstone is added to the genus Harpagopus, under the name of *dubius*, or doubtful, which adjective expresses my views as to this example. It may have been made by an animal analogous to the Hudson River didactyle. But I have no confident opinion on the subject till more light is obtained.

The remaining eight genera of this group contain animals very minute, whose tracks we should once have thought it hardly possible could be preserved in stone, but which in fact are as perfect as those of the larger animals; yet we meet with the same difficulties as in the larger animals in referring them to existing groups, partly, no doubt, because they possessed a combination of characters now found in no single class. Some of those smaller animals were probably Crustaceans; others may have been Myriapods and Insects. But it will need a good deal of attention to the tracks of living invertebrates before we can be sure where to place the fossil species. That study has hardly yet been begun.

One of these small animals has at length been found in a fossil state by Mr. Field at Turner's Falls. Sketches of one of the most perfect of the specimens ever found, are given on Plate VII., figs. 3 and 4, the first of the natural size, and the last somewhat enlarged, as seen under the microscope, also on the wood cut on page 8. That it belonged to the class of articulated or jointed animals, all will admit, because twelve or thirteen distinct joints are obvious. I think it was probably the larva of an insect, or perhaps an adult animal resembling a larva. But I have discussed this question so fully in the early part of this Report, that I will only refer to that place.

The great wonder is, that any of the feet in animals so minute, should have made impressions which have come down to us in such perfection. The most minute of them all, shown on Plates XXIX., fig. 4, and XXX., fig. 3, exhibits four perfectly distinct rows of tracks, not more than one-thirtieth of an inch long. They are so small that most persons would not notice them, though looking attentively at the slab. I calculate that it would require half a million of these tracks to occupy a space as large as a single track of the Otozoum.

The tenth Group embraces what I regard as Annelids, or worms, such as the earth or angle worm, and the leech. They are naked worms, and are described as destitute of feet, though some are armed with hairs or prickles, to help them move forward under ground, where they usually live. They seem to have been abundant in sandstone days, almost as

much so as at present, and their trackways on mud after showers and along the soft shores of ponds or rivers, very much resemble those upon the rocks. Perhaps the Halysichnus laqueatus, Plate XXXVI., fig. 7, is one of the most curious. Its trail appears like a chain; occasioned by the animal's plunging its head sometimes, and sometimes its opposite extremity, into the mud to get a fulcrum for pushing itself forward, or backward, by the muscles connecting its rings. The different species of Unisulcus have left trackways so like what we see after a rain, that we seem to forget the vast interval of time between them.

Such was the Fauna of sandstone days in the Connecticut Valley. What a wonderful menagerie! Who would believe that such a register lay buried in the strata? To open the leaves, to unroll the papyrus, has been an intensely interesting though difficult work, having all the excitement and marvellous developments of romance. And yet the volume is only partly read. Many a new page I fancy will yet be opened, and many a new key obtained to the hieroglyphic record. I am thankful that I have been allowed to see so much by prying between the folded leaves. At first men supposed that the strange and gigantic races which I had described, were mere creatures of imagination, like the Gorgons and Chimeras of the ancient poets. But now that hundreds of their footprints, as fresh and distinct as if yesterday impressed upon the mud, arrest the attention of the sceptic on the ample slabs of our cabinets, he might as reasonably doubt his own corporeal existence as that of these enormous and peculiar races.

And how marvellous the changes which this Valley has undergone in its inhabitants! Nor was it a change without reason. We are apt to speak of these ancient races as monstrous, so unlike existing organisms as to belong to another and quite different system of life. But they were only wise and benevolent adaptations to the changing condition of our globe. One common type runs through all the present and the past systems of life, modified only to meet exigencies, and identifying the same infinitely wise and benevolent Being as the Author of all. And what an interesting evidence of his providential care of the creatures he has made, do these modifications of structure and function present! Did the same unvarying forms of organization meet us in every variety of climate and condition, we might well doubt whether the Author of Nature was also a Providential Father. But his parental care shines forth illustriously in these anomalous forms of sandstone days, and awakens the delightful confidence that in like manner he will consult and provide for the wants of individuals.

The ancient Flora of the Connecticut Valley was probably as peculiar as its Fauna. Gladly would I also develop its vegetable wonders; and, indeed, I am not without numerous specimens for such a work. But if the Ichnology of the sandstone is difficult, still more so, as it seems to me, is its fossil Botany. Before attempting such a work, I feel that some years of careful study would be a prerequisite: a larger number probably than one can hope for, whose sun is so near the horizon as mine. But other suns have already arisen or will rise, whose brighter light shall bring into view the peculiar vegetable forms of American oolitic times.

Who first scientifically described the Fossil Footmarks of the Connecticut Valley?

Here would I gladly close my Report; but the statements below seem to demand something from me upon the above question. Were I to say nothing I fear that I should be understood as admitting claims and charges which I must repudiate.

Some readers of this Report may be aware that about fourteen years ago a discussion took place between me and Dr. JAMES DEANE, of Greenfield, in the American Journal of Science, respecting the first discovery of the Fossil Footmarks. Having each of us had the opportunity to say what we pleased, it has ever since been my determination to trouble the public no more on the subject. But since the death of Dr. DEANE, which occurred during the printing of this Report, some of his friends have thought it proper to revive this discussion, and if correctly reported in the newspapers, to take such ground as does me great injustice, and casts such imputations upon my character that I cannot suffer this last opportunity to pass, without a brief attempt to vindicate myself to the citizens of Massachusetts, and especially to its legislators, who have so liberally published this Report. I refer particularly to the Eulogy upon Dr. DEANE by Dr. H. I. BOWDITCH, and to the statements of T. T. BOUVE, Esq., before the Boston Society of Natural History. Were it not for the high respectability of these gentlemen, I should not feel called on to enter upon this defence.

1. The first inquiry is, *What were the claims of Dr. Deane and his friends?* That he found some good specimens of tracks lying upon the side-walks in Greenfield, and informed me of it, and purchased them for me at my request, is admitted by all parties. But six or seven years afterwards he laid claim to the first scientific investigation of the subject, maintaining that my scepticism and that of Professor B. SILLIMAN, (Senior,) were overcome by his reasoning, and that consequently I was guilty of injustice and dishonorable conduct in giving him credit only for first calling my attention to the tracks, and purchasing the specimens for me. In these claims I understand his eulogists to sustain him, and to reiterate the charge against me.

2. The second inquiry is, *What are my claims?* Not, as already stated, that I found the first tracks; but that I first investigated and described them as a matter of science; that I continued for six years to investigate and describe footmarks almost alone, and published an account of thirty-two species, with twenty-five plates, before Dr. DEANE published any thing on the subject; that the only assistance I derived from him was in the occasional reception of a specimen; that nothing which he ever said had the least influence in overcoming my scepticism, or in helping me reach my conclusions; and that I have ever endeavored to give him all the credit which justice or honor demanded. Hence I complain of the manifest injustice of endeavoring to deprive me of the honor of having first investigated and scientifically described the fossil footmarks.

The chief point of difference, then, between me and Dr. DEANE and his friends, is, whether he or I first scientifically examined and described the Footmarks. In support of my claims I present the following proofs: —

1. *I appeal first to the early history of the subject.* In March, 1835, I received the following letter from Dr. DEANE: —

"In the slabs of sandstone from Connecticut River in Montague or Sunderland, lately brought here, I have obtained singular appearances, new to me, although I presume not to yourself. One of them is distinctly marked with the tracks of a turkey (as I believe) in relief. There were two of the birds side by side making strides of about two feet.

"I was anxious to see the die from which these impressions were struck, and it has now arrived. The tracks, four in number, are perfect, and must have been made when the materials were in a plastic state, and at what period I leave you to tell. I am no geologist, but yet I know that geologists derive much satisfaction from contemplating these remains. I do not know but they may be familiar to you; but if you desire it, I will endeavor to prevent their being converted to the use for which they were brought here."

In my reply to this letter I stated how interesting these impressions would be if they turned out to be real tracks, since the records of geology afforded as yet but one example (in Scotland) of fossil footmarks. But I expressed a fear that they might prove to be the result of other than organic agencies; yet requested Dr. DEANE to secure the specimens for me at my expense, which he did. On the 20th of March he replied to my letter, saying, "I received your letter this morning, which excites my curiosity more than ever, relating to these tracks," and repeating his belief that these markings were "the real impression of the feet of some bird, probably of the turkey species." As I had stated that it would probably be a month or two before I could visit Greenfield, Dr. DEANE sent to me and Professor SILLIMAN some casts of the tracks, reiterating his conviction, from their form and succession, that they were bird tracks. I went to Greenfield a few days after, and a glance at the specimens satisfied me that they were deserving of careful examination. That they had the appearance of tracks no one could doubt, and they bore a strong resemblance to those of some kind of birds. I secured the specimens and determined to enter upon the most careful examination of the subject by every means in my power. That investigation I have now been carrying on for twenty-three years, gaining a little light each year; nor would I even express an opinion on the subject till I had devoted six months to the examination.

It was upon these facts that Dr. DEANE, in 1844, eight years after the discovery of the tracks, based his claims to having scientifically investigated the footmarks earlier than myself. He said that his "three (first) letters, written without a ray of knowledge other than was derived from philosophical inductions, contain the fundamental principles and doctrines applied to the science of these organic remains." Now I appeal to those letters

to show, that at that time and for years afterwards, he had no intention of giving a scientific account of the footmarks; that in fact he did not then understand the subject of geology well enough to undertake it, and that he for a long time intended to leave that matter to me, supposing, whether justly or not, that I ought to be qualified for it. He was ignorant of the then only known example of fossil footmarks; nor did he know but they were common. Nor did he appreciate the difficulties of admitting the existence of birds so early, or think it absurd, as every geologist would, of supposing "a turkey," or "the turkey tribe," to have lived during the red sandstone period. He declared himself to be no geologist; and his statements showed that this was then the literal truth. The thought that he intended to give a scientific investigation of the subject, never entered my mind, nor his either, I apprehend, till years after. He had stumbled upon some interesting specimens, and he gave his first impressions of them, leaving it to me to go into the scientific examination. If he meant to do it, why did he address me at all on the subject? Why especially did he allow me to carry away the only specimens then known? Why, for six or seven years, did he publish nothing, while I had found and described over thirty species? During all that time we were on friendly terms; carrying on a correspondence, and occasionally he sent me a specimen, nor did I suspect all this while that he was not perfectly satisfied.

But what more than Dr. DEANE did I do, that deserves the name of scientific investigation? I perceived on looking at the specimens, as nine out of ten do, who have since looked upon them, that they bore a strong resemblance to tracks, and some resemblance to bird tracks. But knowing how strong were the geological objections to such a conclusion, I set about their examination. Might they not be the result of some freak of water? Were they not some form of veins of segregation, or septaria, or mud veins and furrows, or concretions, or ripple marks, or the result of unequal disintegration? Were they not fucoids, as the New York geologists afterwards maintained? or some organic relics unknown to me? These were the inquiries that must be answered before I would venture to throw down my opinion before an incredulous public. To answer them I spent a large part of six months in exploring all accessible sandstone quarries, where I discovered six other species, and watched the shores of rivers and ponds for the tracks of living animals, and examined the feet of dried specimens in the Cabinets, and also collections and drawings of organic remains. This I call scientific investigation, and this I went through before giving my opinion to the public; and I did it *alone*, receiving no assistance except from the specimens presented me by several gentlemen, and the opinions of distinguished naturalists whom I occasionally consulted. In this way essentially did I go on from 1835 to 1843, before any thing from Dr. DEANE appeared in print on the subject. He, indeed, by misinterpreting a letter of mine to Professor SILLIMAN, endeavored to show that I attempted to muzzle the scientific journals, so that no communication from him should appear (an attempt which none but an insane man would make in this country); but the matter of fact was, that during this long period he did not offer any communication to the journals, so that I certainly did not prevent the appearance of any communication from him, whatever might have been my wishes.

But Dr. Deane contended that my scepticism and that of Professor Silliman were overcome by his letters. A scientific man ought always to be sceptical enough in respect to any new facts, not to admit them without good evidence. All the proof we had in respect to the footmarks, *before we had seen them*, was Dr. Deane's letters giving us the impressions of his own mind from an examination of one or two specimens, while the same letters contained evidence that he did not at all understand the difficulties of the subject, and, therefore, his opinion merely awakened a desire to see the specimens, and when we did see them, although they appeared to be tracks, we were not prepared to take and maintain that ground till we had gone into a thorough examination. That investigation had not been entered upon, but, as I understood it, was left for me to undertake; and though I have been pursuing it for twenty-three years, on many points, as my Report testifies, I am still sceptical. Dr. Deane's opinion I regarded as merely the first impressions made by the specimens upon the mind of an intelligent man, who was not acquainted with the difficulties in the case, and had made no investigation of it, save to look occasionally for a fortnight at the slabs of one species as they lay in the streets. If such an examination and the expression of such an opinion entitles Dr. Deane to the credit of having made a scientific investigation of the subject, then Pliny Moody, Esq., of South Hadley, as I afterwards found, could set up a prior claim, for in 1802 he dug up the first fossil footmark ever preserved in this Valley, of which he and his neighbors were in the habit of speaking, as the tracks of "poultry," or of "Noah's raven."

In thus speaking of Dr. Deane's want of acquaintance with geology and fossil footmarks in 1835, let me not be understood as describing him in subsequent years. For as he says, my letter excited his curiosity, and I doubt not he then began to study the whole subject and with success; so that he was able to produce those papers on footmarks which have done him so much credit; nor should I dissent from the resolution of the Boston Society of Natural History, who "highly appreciating the value and importance of his labors in the investigation and elucidation of the fossil footprints of the Connecticut Valley, recognize in his death a great loss, not only to themselves, with whom he was associated, but to all who feel interested in the progress of science."

2. For my second argument *I present a Bibliography of Fossil Footmarks:* that is, a list of the papers and volumes published on the subject. My object is simply to show who did publish such papers for the first eight years after their discovery. I extract the list from a complete one, extending to the present time, prefixed to this Report:

1. 1836, January.—Ornithichnology, by E. Hitchcock in American Journal of Science, Vol. 29, p. 307. 34 pages and 3 Plates.
2. 1837.—Ornithichnites in Connecticut, by E. Hitchcock. American Journal of Science, Vol. 31, p. 174.
3. 1837.—Same, by Professor B. Silliman, p. 165, same volume.
4. 1837.—Fossil Footsteps in Sandstone and Graywacke, by E. Hitchcock. American Journal of Science, Vol. 32, p. 174.
5. 1838.—Newly discovered Ichnolites at Middletown, Connecticut, by William C. Redfield. American Journal of Science, Vol. 33, p. 201.

6. 1839.—Note to Professor Conrad's remarks on Ornithichnites; by Professor Silliman. American Journal of Science, Vol. 35, p. 246.
7. 1841.—Final Report on the Geology of Massachusetts, with 62 pages and 22 plates on footmarks, by E. Hitchcock.
8. 1841.—Report of Professor H. D. Rogers and others on the Ornithichnites of Massachusetts, observed and described by Professor Hitchcock, of Amherst. American Journal of Science, Vol. 41, p. 165.
9. 1842.—Description of five new species of Fossil Footmarks, by E. Hitchcock. Transactions of Association of American Geologists and Naturalists, Vol. 1, p. 254.
10. 1842.—New Species of Footmark with Rain Drops, from Portland, Connecticut, by William C. Redfield. American Journal of Science, Vol. 43, p. 172.
11. 1843.—Notice of newly discovered Fish Beds and a Fossil Footmark in the Red Sandstone Formation of New Jersey, by William C. Redfield. American Journal of Science, Vol. 44, p. 134.
12. 1843.—Ornithichnites of the Connecticut River Sandstone and the Discoveries of New Zealand, containing Dr. Deane's correspondence with Dr. Mantell; by Professor B. Silliman. American Journal of Science, Vol. 45, p. 177.

My object in giving this list is to show that before Dr. Deane published any thing on the footmarks, I had brought out five papers upon them, containing more than one hundred pages and twenty-six plates, and others, also, during the seven years that elapsed, had published descriptions of them. And yet it is now represented that I was behind Dr. Deane, and in all that I did, was acting only an inferior part, and carrying out "the fundamental principles derived from philosophical induction" which he had taught me!

3. *For my third argument I refer to a Report, made to the American Association of Geologists and Naturalists*, "on the Ornithichnites or Footmarks of extinct Birds in the new red sandstone of Massachusetts and Connecticut, observed and described by Professor Hitchcock of Amherst," signed by Professors Henry D. Rogers, Lardner Vanuxem, Richard C. Taylor, Ebenezer Emmons and T. A. Conrad. When in 1836 I published my first paper on footmarks, but few of the distinguished geologists on either side of the Atlantic admitted my conclusions. But the subject grew in interest, and in 1840 the American Association of Geologists and Naturalists appointed the above committee of eminent geologists to visit the localities and report. I refer to it here to show who was regarded by them as the scientific describer of the footmarks, and who must bear the odium if a false representation had been made, or receive the credit if his conclusions were admitted. The title of the Report shows who: indeed, I alone am mentioned as having formed scientific conclusions as to the tracks; and after stating with great clearness the arguments on both sides, the Committee state their belief unanimously, that "the evidence entirely favors the views of Professor Hitchcock." This was five years after my first publication, so that up to that time no competitor, either for the odium or the honor, had appeared.

4. As a fourth proof that I first made a scientific investigation of the footmarks, I present some special testimony from Professor Silliman and Dr. Deane. I cannot see why

the facts just detailed do not show that this matter was by general consent committed to me. But a few other quotations will I think make this point still more certain.

In a letter to me of August 6th, 1835, Professor SILLIMAN says: "I am much gratified that you are seriously at work upon the turkey tracks, or bird tracks, or whatever kind they may be; and you may rest assured that I shall publish nothing upon the subject until I receive it from you. I will therefore expect you to do justice to Dr. DEANE," &c. "My impressions are so strong in favor of the genuineness of the discovery,—judging only from the imperfect copy I have in plaster,—that I feel exceedingly desirous to have the matter investigated; and I do not know in whose hands it can be better placed." Does this read as if Professor SILLIMAN thought the matter had been already investigated, and the philosophical induction drawn?

Read too the testimony of Dr. DEANE in 1843, eight years afterwards, in the first communication he ever made to a scientific journal on the subject. Describing certain slabs from Turner's Falls, he says: "These magnificent specimens have been inspected by Professor Hitchcock and Professor Silliman: to the former properly belongs the technical and complete description of them as his peculiar province. I therefore most willingly decline this difficult performance in (out of) respect to him, for to his successful labors, the subject of fossil footmarks owes its claims as an essential element of the science of organic geology." Really, how little short of a full admission of my claims does this passage come! Alas, how different from the ground taken by him only the next year, that his first letters to me, "written without a ray of knowledge other than was derived from philosophical induction, contain the fundamental principles and doctrines applied to the science of these organic remains."

5. *Fifthly, I appeal to personal consciousness.* No facts in my life are more vividly impressed upon my memory than those relating to the footmarks. I remember when I received Dr. DEANE's first letter, that I feared it would turn out as I had known in many similar cases where tracks had been described to me, to be something quite different. But as soon as I saw the specimens, I perceived the phenomena to be worthy of careful research. The thought never occurred to me that the investigation had already been made, and "the philosophical induction" drawn. That work I understood was committed to me: for why else were the specimens allowed to come into my hands, or why was I consulted at all on the subject? I went about it as if the work were entirely unaccomplished. Dr. DEANE frequently inquired of my progress in it, and sent me several specimens to help me in it, and was anxious to know when I should publish upon it. Other gentlemen, also, gave me specimens, as Dr. JOSEPH BARRATT, Colonel JOHN WILSON, Colonel DAVID BRYANT, N. P. AMES, HENRY HANMER, and DEXTER MARSH. But this was essentially all the help I received. I felt that I was working alone, and the thought occurred to me, that if I should succeed in establishing any correct conclusions, I might be sure that no one would ever doubt that the investigations were original, or claim the credit. The reception of my conclusions was such at first and for years, that no one would be apt to contend for my cypress wreath. I remember well the discouragement and heart sickness that often came over

me during those six years when I had to maintain the conflict alone. But when the cypress began to change into the laurel,—when it was obvious that the learned world were falling in with my leading conclusions, and the subject had become in their view of deep interest, with what surprise did I find the claim set up, that the honor belonged to another, that I had only been carrying out his "philosophical induction," and endeavoring "to rob him of the honor of being the first discoverer of the bird tracks;" thus not only giving me a subordinate place in this work, but casting a dishonorable imputation upon my character. All this I say emphatically, is opposed to my past and present consciousness, as much as if I were now told that I had never been the President, but only a student, of Amherst College, or as if I were charged with theft, or murder, or some other foul crime, against which my whole nature revolts, as it does against any intentional effort to rob any one of the honor due him.

6. Let us in the sixth place inquire *what credit I have given, and how I have treated Dr. Deane?*

In my first communication on the subject in 1836, I said that "my attention was first called to the subject by Dr. JAMES DEANE of Greenfield, who sent me some casts of impressions on a red micaceous sandstone from the south part of Montague, for flagging stones. Through the liberality of the same gentleman I soon after obtained the specimens themselves, from which the casts were taken," &c.

In my Final Report on the Geology of Massachusetts in 1841, I attached Dr. DEANE's name to a species of footmark, saying, "It is a beautiful species; I have dedicated it as a testimony of respect to Dr. JAMES DEANE of Greenfield, who first called my attention to the subject of fossil footmarks."

In the Transactions of the Association of American Geologists and Naturalists, in 1843, I said, "Plate XI., fig. 4, exhibits a slab of this species which was originally in the Cabinet of Dr. DEANE; but he has kindly divided it, in order that one row of these tracks should be placed in my collection," &c.

In my Report on Ichnolithology to the Association of American Geologists and Naturalists in 1844, and in the discussion that followed, I said, "I admit Dr. DEANE to have been in a popular sense the original *discoverer* of the footmarks; and had it not been for his scientific discernment they would still have remained undiscovered." "While we must admit that Mr. MOODY, Dr. DWIGHT, and Mr. WILSON were also original discoverers of the footmarks, much higher credit is due to Dr. DEANE. He did not content himself with speaking of them as objects of curiosity, but took measures to bring them under the notice of those whose professional business it was to examine such objects," &c.

In the present Report, published since his death, I say of the first specimens, "They were observed by Dr. JAMES DEANE, who sent casts of them to me, secured them for my Cabinet, and gave it as his opinion, from their form and succession, that they were made by birds."

To show still farther my feelings towards Dr. Deane, I would state, that since he, like myself, had not enjoyed the benefits of a public education, I applied for, and secured for him, from the Trustees of Amherst College, in 1838, the honorary degree of Master of Arts.

Now what more did justice or honor require me to say or do in this case? Ought I to have said that my scepticism, as he calls it, was overcome by his letters? I should then have stated what was not true; for I was certain then, and am certain now, that neither his statements nor opinions had the slightest influence upon me. I knew them to be merely the first impressions of an intelligent man, who had not studied geology, nor made any investigations on the subject, except to look at a few specimens; they were, in fact, such conclusions as every discerning man comes to on first inspecting the footmarks; but whether true or not, remained to be proved. Ought I to have stated that his three first letters were "philosophical inductions" containing "the fundamental principles" of ichnology? Those letters show that he was not then enough acquainted with geology or ichnology to make philosophical inductions of this sort; and because they show this, those letters never would have seen the light, had I not been forced in self-defence to bring them out. I acknowledged all the assistance Dr. Deane or any one else gave me by specimens, and tried to show my gratitude by personal favors. But all this availed nothing in later times, unless I would acknowledge what I knew to be false, that he preceded me in a scientific investigation of ichnology.

7. In view of all these facts, *I feel constrained to protest against the manifest injustice of the attempt to deprive me of the credit of the most original scientific investigations of my life;* to represent me as a mere expounder of the views of another, and as ungenerously attempting to rob him of the honor which I knew belonged to him. It is hard to bear all this, opposed as it is to my personal consciousness for the last twenty-three years, and to all the moral sentiments of my heart. I know certainly that I commenced the study of footmarks with no aid save that of specimens. I groped my way alone without guide, and almost without counsellor, for several years. Against me only during all that time were the shafts of reason and of satire aimed, nor was it till I had maintained the struggle alone for five or six years, and a gradual acquiescence in my views had taken place, that any rival claim for the honor of original investigation was set up. In the same manner, for nearly twenty years more, have I labored on, gaining each year a little deeper insight between the close-shut leaves of the fossil volume; but still, though aided in later years by the collateral researches of Dr. Deane and other naturalists, finding myself only at the commencement of the work, obliged to leave to others many a hiatus, and many a question unresolved. If this has not been from the first original investigation, then nothing in my life has been. But I *know* it to have been so; and how painful, as the last sands of life are falling, to feel compelled to offer this defence, lest I should seem to acquiesce in the charge or the insinuation of unrighteous claims on my part, or injustice to others. Oppressed with the infirmities of advanced life, fain would I live in harmony with all, and especially observe the adage, *de mortuis nil, nisi bonum.* And were I alone

concerned, I would bear all in silence; but I do feel, and ought to feel, a desire to leave to the children who may survive me; to the literary institution with which I have been connected for more than thirty years; and to the citizens of that Commonwealth, which has been so liberal and generous towards my scientific labors; I do desire to leave to them a character free from dishonorable imputation, and to let them know what I claim as to the footmarks, and on what ground I claim it. This has been the most laborious and difficult of the scientific labors in which I have engaged; and if I am to be set down as a copyist and plagiarist here, there is no other effort of my life on which such a charge may not be more justly fixed. I cannot, indeed, believe that those who make such charges to honor the dead, intend to do injustice to the living. But their sincerity does not make the effects less injurious to me and mine. Can I, then, do less, unpleasant as it is, than to attach this defence and protest to the last work on Ichnology which I shall ever publish?

NOTE.—Just as this last sheet was passing through the press, I made a large additional purchase of fossil footmarks ($700 worth) for the Appleton Cabinet, from ROSWELL FIELD; so that I am now able to say that the tracks of every species but one (the Hoplichnus equus) described in this Report may now be found in that Cabinet.

A TABULAR VIEW

OF THE CHARACTERS OF THE

LITHICHNOZOA OF THE CONNECTICUT RIVER SANDSTONE.

			DIVARICATION.						LENGTH.													DISTANCE.							VERSED SINE.				WIDTH.					
	Number of feet.	Number of toes.	Of the outer front toes.	Of the inner and second front toes.	Of the second and third front toes.	Of the hind toe and middle front toe.	Of the third and fourth front toes.	Of the fourth and fifth front toes.	Of the inner toe.	Of the second toe.	Of the third toe.	Of the phalangeal impressions of the inner toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the second toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the third toe, beginning with the proximal phalanx.	Of the fourth front toe.	Of the fifth front toe.	Of the hind toe.	Of the claw of the mid-toe.	Of the foot.	Of the step.	Of the heel.	Of the middle front toe beyond the rest.	Between the tips of the outer toes in front.	Between the tips of the inner and second front toes.	Between the middle front and outer toe.	Between the middle front and hind toe.	Between the tracks of the hind and fore feet.	Of the heel from the line of direction.	Of the inner toe.	Of the middle toe.	Of the outer toe.	Of the fourth toe.	Of the toes.	Of the heel.	Of the Trackway.	Of the caudal appendage.	Angle between the axis of the foot and the median line.	Number of phalangeal impressions reckoning outwards.
CUNICHNOIDES.																																						
1. marsupialoideus, Hind foot,	4	4	–	–	–	–	–	–	0.6	0.6	0.6	– –	– –	– –	0.6	–	–	–	1.5-2.3	16-18	–	–	–	–	–	–	0.3	2.5	–	–	–	–	0.6.	–	11.	–	–	–
Fore foot,		4	–	–	–	–	–	–	0.5	0.5	0.5	– –	– –	– –	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–
ANOMŒPUS.																																						
1. major, Hind foot,	4	3	26°	20°	10°	–	–	–	3.5	6.	4.2	1.6-1.4	1.6-1.6-1.6	0.6-1.1-1.4?	–	–	–	1.2	16.5	10.-22.	9.	3.2	4.	3.5	4.	–	–	–	–	–	–	–	1.5	2.1	17.	2-3 5	–	2-3-4?
Fore foot,		5	83°	6°	32°	–	20°	26°	1.	1.5	1.6	– –	– –	– –	1.3	0.7	–	0.2	2.4	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–
2. minor, Hind foot,	4	3	42°	20°	22°	–	–	–	2.3	3.	3.3	0.7-0.8	1.1-1.-0.7	0.8-0.8-0.6-0.6	–	–	–	–	8.2	9.	4	1.2	2.7	1.9	1.9	–	–	–	–	–	–	–	0.8	–	8.	–	20°	3?-3-5
Fore foot,		5	114°	40°	50°	–	12°	11°	1.	1.2	1.4	0.4-0.4	0.3-0.3-0.4	0.4-0.3-0.3-0.3	1.3	0.9	–	–	–	–	–	–	–	–	–	–	–	2.	–	–	–	–	–	–	–	–	–	–
ANISOPUS.																																						
1. Deweyanus, Hind foot,	4	4	40°	12°	23°	–	6°	–	1.	1.5	1.7	– –	– –	– –	1.5	–	–	–	1.35	7-7.5	–	–	1.	–	–	–	0-0.2	–	–	–	–	–	0.3	–	2-3	–	15°-30°	–
Fore foot,		5	107°	53°	13°	–	18°	24°	0.3	0.8	1.	– –	– –	– –	1.	0.6	–	–	1.08	–	–	–	0.75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. gracilis, Hind foot,	4	4	40°	15°	10°	–	15°	–	0.4	0.8	0.9	– –	– –	– –	0.85	–	–	0.1	1.	5.6	–	–	0.8	–	–	–	–	0.25-0.6	–	–	–	–	0.1-0.15	–	2.	–	10°-20°	2-3-3-3?
Fore foot,		5	60°	15°	20°	–	10°	10°	0.25	0.5	0.6	– –	– –	– –	0.45	0.2	–	–	0.6	–	–	–	0.4	–	–	–	0-0.1	–	–	–	–	–	0.05-0.075	–	–	–	–	–
BRONTOZOUM.																																						
1. giganteum,	2	3	40°	20°-25°	15°	–	–	–	10.	12.5	12.5	3.8-4.2	3.4-3.1-2 6	3.3-3-2.1-2.4	–	–	–	1.75	14-18	3-5 ft.	–	5.5	12.	7-8	7.45	–	–	0.-5	–	–	–	–	2-3	–	18.	–	0°-10°	2-3-4
2. minusculum,	2	3	50°	25°	25°	–	–	–	6.25	7.5	8.5	2.5-2.5	2.5-2.25-2.25	2.5-2.1-1.75-1.75	–	–	–	1.5	12.	20-27	–	4.	7.3	5.3	5.3	–	–	–	–	–	–	–	2.7-1.5	–	12.5	–	0°-20°	2-3-4
3. tuberatum,	2	3	25°	17°	8°	–	–	–	5.5	6.75	8.	2 75-2.	1.88-2.-2.	1.5-1.62-1.37-2.25	–	–	–	1.	9.75	31.	–	2.62	6.	4.5	3.62	–	–	–	–	–	–	–	1.75-2	–	8.	–	0°-10°	2-3-4
4. exsertum,	2	3	30°	15°	15°	–	–	–	4.	6.25	6.	1.5-1.5	2.-1.5-1.5	1.25-1.25-1.44-1	–	–	–	1.25	8.75	30.	–	3.33	4.75	4.5	3.5	–	–	–	–	–	–	–	1-1.75	–	6.	–	0°-5°	2-3-4
5. validum,	2	3	36°	22°	14°	–	–	–	4.5	5.5	5 75	2.3-1.5	1.9-1.6-1.5	1.3-1.2-1.1-1.4	–	–	–	1.	8.2	33.	–	2.7	5.3	4.	3.7	–	–	–	–	–	–	–	1.2-1.8	–	6.	–	0°-5°	2-3-4
6. Sillimanium,	2	3	25°	8°-11°	15°-18°	–	–	–	2.8-3.2	4-4.5	4-5	1.4-1.2	1.1-1.4-1.1	0.8-0.8-0.7-8.	–	–	–	0.8-1	5.75-6	12-20	–	2-2.2	3-3.5	2.2-3	2.5	–	–	0-1	–	–	–	–	0.8-1.2	–	4.5	–	0°	2-3-4
7. isodactylum,	2	3	45°-60°	20°	28°-38°	–	–	–	2.4-2.6	3-3.2	2.8-3.8	1.-0.8-1.	0.9-0.8-0.9	0.7-0.7-0 5-0.4	–	–	–	0.6-0.8	4.2-4.5	5.5-6.5	–	1.2	4.4	1.9	2.3	–	–	0-2	–	–	–	–	0.55-0.8	–	5.	–	0°-25°	2-3-4
AMBLONYX.																																						
1. giganteus,	2	3	30°	12°	18°	–	–	–	6.	7.5	9.	2.3-2.6	2.-2.3-2.3	2.4-1.9-1.4-2	–	–	–	1.3	11.25	32.	–	3.2	7.3	5.	5.	–	–	–	–	–	–	–	2.2-2.8	–	12.	–	0°	2-3-4
2. Lyellianus,	2	3	20°	10°	10°	–	–	–	4.4	5.8	5.3	1.8-1.9	1.7-1.7-1.8	1.2-1.2-0.8-1.5	–	–	–	0.9	8.2	30.	–	3.	4.8	3.7	3.9	–	–	1.	–	–	–	–	0.6-1.7	–	6.	–	0°-10°	2-3-4
GRALLATOR.																																						
1. cursorius,	2	3	26°	13°	13°	–	–	–	1.3	2 2	1.7	0.6-0.5	0.7-0.7-0.5	0.4-0 31-0.35-0.45	–	–	–	0.3	2.9	25.	–	1.2	1.2	1.3	1.4	–	–	–	–	–	–	–	0.25-0.4	–	2.	–	0°	2-3-4
2. tenuis,	2	3	45°	25°	28°	–	–	–	1.1	2.1	1.3	0.5-0.4	0.3-0.4-0.7	0.3-0.3-0.2-0.2	–	–	–	0.3	2.7	9.	–	1.5	1.5	1.7	1.6	–	–	0.25	–	–	–	–	0.2-0.3	–	2.5	–	0°-5°	2-3-4
3. gracillimus,	2	3	50°	28°	23°	–	–	–	1.55	2.	1.8	0.6-0.5	0.7-0.5-0.4	0.45-0.45-0.35-0.3	–	–	–	0.4	2.5	7-8	–	0.8	2.1	1.4	1.4	–	–	0.5	–	–	–	–	0.3-0.5	–	3.5	–	0°-10°	2-3-4
4. cuneatus,	2	3	30°	12°	16°	–	–	–	2.2-2.4	3.4-3.7	3-3.1	0.85-0.85	1.-0.85-0.85	0.6-0.7-0.6-0.7	–	–	–	0.7	4.9-5	22-24	–	2-2.2	2.9	2.5-2.7	2.3-2.7	–	–	0.5	–	–	–	–	0.5-0 6	–	3.5	–	0°	2-3-4
5. formosus,	2	3	50°	–	–	–	–	–	3.9	5.	4.4	1.1-1.2	1.5-1.4-1.5	1-0.9-0.8-1.	–	–	–	0.8	6.8-7.3	27.	–	3.	4.4	3.3	4.1	–	–	–	–	–	–	–	0.8-1.2	–	6.	–	3.5°	2-3-4
ARGOZOUM.																																						
1. Redfieldianum,	2	3	75°	30°	45°	–	–	–	12.	8.	9.5	– –	– –	– –	–	–	–	2.	12.5	30.	–	6.	12.	7.8	9.	–	–	–	–	0.7	–	–	0.4-1.	–	13.	–	0°-10°	–
2. dispari-digitatum,	2	3	40°-55°	18°-30°	20°-25°	–	–	–	3.	5.	3 5	– –	– –	– –	–	–	–	–	5.5	15.	–	2.25	3.	3.	2.75	–	–	0.6	–	–	–	–	0.25	–	4.	–	0°	–
3. pari-digitatum,	2	3	80-100°	40°-50°	40°-50°	–	–	–	0.9	1.3	1.	– –	– –	– –	–	–	–	–	1-1.6	6.	–	0.9	1.7	1.1	1.4	–	–	0-0.1	–	–	–	–	0.2	–	1.7	–	0°-30°	–
PLATYPTERNA.																																						
1. Deaniana,	2	3	60°-70°	40°-45°	25°-30°	–	–	–	1.5	3.	2.	– –	– –	– –	–	–	–	–	4-4.5	9-12	1.1-1.2	1.8	2-2.5	2-2.2	2-2.3	–	–	–	0.17	0.12	0.22	–	0.2	0.9	3?	–	10°	–
2. tenuis,	2	3	45°-60°	20°-30°	25°-30°	–	–	–	1.	2.	1.3	– –	– –	– –	–	–	–	–	2.1	7.	0.6	0.9-1.1	1.1-1.7	1.1-1.4	–	–	–	–	–	–	–	–	0.1	0.6	2?	–	–	–
3. delicatula,	2	3	40°	22°	18°	–	–	–	0.65	1.1	0.75	– –	– –	– –	–	–	–	–	1.5	3.	0.4	0.5	0.6	0.6	0.55	–	–	–	–	–	–	–	0.1	0.3	2.	–	–	–
4. recta,	2	3	36°	10°	27°	–	–	–	2.5-3.5	3.75-5.	2.5-4.1	– –	– –	– –	–	–	–	–	3.75	5.5	–	1.4	2.5	1.6	2.	–	–	1.75	–	–	–	–	0.3	–	5.5	–	–	–
5. varica,	2	3	75°	23°	52°	–	–	–	3.	3.6	2.	– –	– –	– –	–	–	–	–	5.	8-12	1.1	2.	3 7	1.5	3.3	–	–	5.	0.3	0.4	0.15	–	0.4	2.	12.	–	20°	–
6. digitigrada,	2	3	80°	43°	37°	–	–	–	1.2	1.5	1.2	– –	– –	– –	0.25	–	–	–	–	4-4.5	–	–	1.6	1.	1.	–	–	0.6	0.1	0.15	–	–	0.3	0.8	3.	–	10°-20°	–
7. gracillima,	2	3	70°	20°	50°	–	–	–	1.	1.5	1.25	– –	– –	– –	–	–	–	–	1.6	5-5.5	–	0.6	1.4	–	–	–	–	0.2-0.9	–	0.12	–	–	0.15	–	3.	–	30°	–

A TABULAR VIEW—Continued.

				DIVARICATION.						LENGTH.													DISTANCE.							VERSED SINE.				WIDTH.					
		Number of feet.	Number of toes.	Of the outer front toes.	Of the inner and second front toes.	Of the second and third front toes.	Of the hind toe and middle front toe.	Of the third and fourth front toes.	Of the fourth and fifth front toes.	Of the inner toe.	Of the second toe.	Of the third toe.	Of the phalangeal impressions of the inner toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the second toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the third toe, beginning with the proximal phalanx.	Of the fourth front toe.	Of the fifth front toe.	Of the hind toe.	Of the claw of the middle toe.	Of the foot.	Of the step.	Of the heel.	Of the middle front toe beyond the rest.	Between the tips of the outer toes in front.	Between the tips of the inner and second front toes.	Between the middle front and outer toe.	Between the middle front and hind toe.	Between the tracks of the hind and fore feet.	Of the heel from the line of direction.	Of the inner toe.	Of the middle toe.	Of the outer toe.	Of the fourth toe.	Of the toes.	Of the heel.	Of the Trackway.	Of the caudal appendage.	Angle between the axis of the foot and the median line.	Number of phalangeal impressions reckoning outwards.
Ornithopus.																																							
1. gallinaceus,		2	4	88°	35°	45°	145°	–	–	1.7	3.	2.	–	–	–	–	–	1.7	–	3.8	7.	1.	1.5	2.7	2.	2.	4.4	–	–	–	–	–	–	0 12–0.20	0.5	3.5?	–	–	–
2. gracilior,		2	4	90°	35°	57°	105°	–	–	–	1.1	1.2	–	–	–	–	–	0.9	–	1.6	–	–	0.75	1.8	1.	1.2	2.	–	–	–	–	–	–	0.12–0.20	–	2.5?	–	–	–
Tridentipes.																																							
1. ingens,		2	4	107°	50°	58°	130°	–	–	8.	9.5	5.7	–	–	–	–	–	5.	–	1.8–2.5?	40–72	9.	5.5	11.3	7.	7 3	16.5	–	–	–	0.3–0.7	0 3–0 5	–	0.4–1.1	3.	–	–	–	–
2. elegans,		2	4	125°	65°	60°	140°	–	–	1 8	2.8	2.2	–	–	–	–	–	1.8	–	5.	10–20	2.4	2.	3.5	2.5	2.6	5.3	–	0.5–3.5	–	0.2	–	–	0.26–0.42	0.5	7.	–	0°–10°	–
3. elegantior,		2	4	75°	32°	44°	140°	–	–	0.6	1.	0.9	–	–	–	–	–	0.4	–	1.8	5.3	0.7	0.6	1.1	0.8	0.9	–	–	–	–	–	–	–	0.14–0.25	–	1.75	–	0°–10°	–
4. insignis,		2	4	95°	45°	50°	100°	–	–	4.3	5.3	4.3	–	–	–	–	–	3.2	–	6–7	16–23	1–2	2.5	6.3	4.	4.	6.8	–	3.	0.4	0.6	0.2	0.2	0.5–0.7	1.5	12.5	–	10°	–
5. uncus,		2	4	90°	48°	44°	70°	–	–	1.7	2.2	1.4	–	–	–	–	–	1.1	–	3.2	45–5	1.1	1.	2.2	1.4	1.6	2 3	–	1.5	0.15	0.2	0.1	0.1	–	0.9	6–10	–	5°–20°	–
Gigantitherium.																																							
1. caudatum,		2	4	53°	22°	30°	120°	–	–	13.5	15.2	13.	–	–	–	–	–	3.3	1.	17.5	39	–	4.3	11.5	6.6	7 5	17.25	–	–	–	–	–	0.4	0.7–3.5	–	12.	0.25–0.50	0°	–
2. minus,		2	3	43°	30°	12°	–	–	–	5.8	5.4	5.1	1.3–1.25–1.9	1.4–1.5–1.3	–	–	–	–	.8	8.	26–34	–	2.7	5.8	4.7	3 3	–	–	–	–	–	–	–	0.9–1.3	–	6.5	0.15	–	–
Hyphepus.																																							
1. Fieldi,		2	4	50°	23°	28°	152°	–	–	3.	5.	2.9	–	–	–	–	–	1.	–	5.	6.	–	2.	2.8	2.3	2.5	5.2	–	1.5	–	–	–	0.25	–	–	5.3	0.15	5°	–
Corvipes.																																							
1. lacertoideus,	Hind foot,	4	3	75°	40°	35°	–	–	–	1.7	1.7	1.7	–	–	–	–	–	–	.2	2.6	1.7–2.7	0.9	–	–	–	–	–	–	0–5	–	–	0.2	–	0.25	–	4.6	–	0°–10°	–
	Fore foot,		5	–	–	–	–	–	–	0.6	0 8	0.75	–	–	–	0.4	0.4	–	–	1.3	–	–	0.6	–	–	–	–	0.55	–	–	–	–	–	0–9–1.2	–	–	–	–	–
Tarsodactylus.																																							
1. caudatus,	Hind foot,	4	4	42°	20°	22°	–	–	–	1.8	2.9	2.2	–	–	–	–	–	–	.25	2.6	13.	–	1.1	1.6	1.4	1.4	–	0.2	–	–	–	–	–	–	–	7.	–	20°	–
	Fore foot,		5	95°	23°	20°	–	25°	25°	0.5	1.2	1.5	–	–	–	1.65	0.25	–	–	1.15	–	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	–	–	–
Apatichnus.																																							
1. circumagens,	Hind foot,	4	4	75°	35°	40°	110°	–	–	1.7	2.6	2.1	–	–	–	–	–	1.	.3	5.	13.	2.5	1.25	2 3	1.4	1.7	3 1	0.1	0 5	–	–	–	–	0.4–0.6	–	4.5	0.25	10°	–
	Fore foot,		5?	–	–	–	–	–	–	–	1.	–	–	–	–	–	–	–	–	1.3	–	0.5	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–
2. bellus,	Hind foot,	4	4	60°	30°	30°	–	–	–	0.5	0.9	0.7	–	–	–	–	–	0.2	–	1.	6 8	–	0 3	0.7	–	–	–	0–6	1.5–2.5	–	–	–	–	0.15	–	2.5	–	10°–30°	–
	Fore foot,		3	40°	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5.	–	0.5	–	–	–	–	–	–	–	–	–	–	–	0 12	–	–	–	1°	–
Plesiornis.																																							
1. quadrupes,	Hind foot,	4	3	70°	40°	30°	–	–	–	2.1	2.5	2.5	–	–	–	–	–	–	–	3.8	13.5	–	1.4	3.5	2.4	2.2	–	–	–	–	–	–	–	–	–	7.5	–	5°	2–3–4?
	Fore foot,		3	66°	35°	–	–	–	–	2.7	3.6	2.7	–	–	–	–	–	–	–	3 1	–	–	1.1	3.	3.	2.2	–	–	–	–	–	–	–	0 7	–	–	–	5°	–
2. pilulatus,	Hind foot,	4	3	70°	35°	35°	–	–	–	1.3	2.1	2.1	–	–	–	–	–	–	–	2.1	7.2	–	1.1	1.5	1.1	1.1	–	–	–	–	–	–	–	–	–	2.	–	0°	–
	Fore foot,		3	70°	40°	30°	–	–	–	0.8	1.4	1.	–	–	–	–	–	–	–	1.4	–	0.25	–	1.1	1.1	0.9	–	–	–	–	–	–	–	0.2	–	–	–	0°	–
3. æqualipes,		2	3	90°	50°	40°	–	–	–	0.6	1.	0.7	–	–	–	–	–	–	–	1.1	3.2	–	0.5	1.2	0 6	0.7	–	–	–	0.1	0.075	0.05	–	–	–	2.	–	–	–
Typopus.																																							
1. abnormis,		2	4?	35°	20°	15°	–	–	–	1.3	2.8	1.8	–	–	–	–	–	–	–	4.	18.	0.72	0.5–1.4	2.8	1.8	2.	–	–	2.5	–	–	–	–	0.3	0.25	7.	–	–	–
2. gracilis,		–	4?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.	–	1.	–	–	–	–	–	–	–	–	0.2	1 2	–	0.1	0.1	–	–	–	–
Polemarchus.																																							
1. gigas,		4	4	45°	20°	25°	80°	–	–	11.2	8.5	8.3	–	–	–	–	–	2.5	–	14 8	48?	3.8	3.2	6.6–8.7	4–4.6	5.5–5.7	13.	–	–	0.45	0.9	0.3	–	0.5	3.9	12?	–	–	–
Plectropterna.																																							
1. minitans,	Hind foot,	4	4	75°	38°	37°	80°	–	–	3.	4.8	3.4	–	–	–	–	–	1.4	–	9 1	16.	4.3	–	4.	2.7	3.5	6.	–	–	–	–	–	–	0.5	–	9.	–	–	–
	Fore foot,		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. gracilis,	Hind foot,	4	4	94°	57°	37°	105°	–	–	1.1	1.8	1.5	–	–	–	–	–	0.6	–	3.8	7.	2.	–	2.	1.5	1.	2.2	3.	–	–	–	–	–	0.2	–	5.	–	–	–
	Fore foot,		5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. angusta,	Hind foot,	4	4	47°	22°	25°	95°	–	–	2.	2.8	1.8	–	–	–	–	–	0.7	–	4.2	12.	1.4	1.25	1.6	1.3	1.7	3.5	–	–	–	–	–	–	0.2	–	2.7	–	1°	–
	Fore foot,		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4. lineans,	Hind foot,	4	4	67°	25°	42°	63°	–	–	1.2	1.9	1.1	–	–	–	–	–	0.5	–	2.6	10.	0.7	0.9	1.0	0.8	1.2	1.9	0.5	–	–	–	–	–	0.12	–	1.4	–	4°–6°	–
	Fore foot,		4	–	–	–	–	–	–	1.	1.	–	–	–	–	–	–	–	–	1.	–	–	–	–	–	–	–	–	–	0.15	0.15	–	–	.07	–	–	–	–	–
Triænopus.																																							
1. leptodactylus,	Hind foot,	4	4	35°–40°	15°–20°	15°–20°	30°–40°	–	–	–	2.5–3.6	2–25	–	–	–	–	–	0.8	–	4–4.9	7?	1.4–2	1.5	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–		–
	Fore foot,		4	50°	25°	25°	115°	–	–	1.5–2	2 3–3.2	1.5–2.2	–	–	–	–	–	0.9	–	2.8–3.9	–	3–7	–	1.5–2	1.1–1.8	1.3–2	2.9–4.1	–	–	0.15	1.15	0.05	–	–	0.2	2.5	–	–	–

A TABULAR VIEW—Continued.

		Number of feet.	Number of toes.	DIVARICATION. Of the outer front toes.	Of the inner and second front toes.	Of the second and third front toes.	Of the hind toe and middle front toe.	Of the third and fourth front toes.	Of the fourth and fifth front toes.	LENGTH. Of the inner toe.	Of the second toe.	Of the third toe.	Of the phalangeal impressions of the inner toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the second toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the third toe, beginning with the proximal phalanx.	Of the fourth front toe.	Of the fifth front toe.	Of the hind toe.	Of the claw of the middle toe.	Of the foot.	Of the step.	Of the heel.
Harpedactylus. 1. gracilis,	Hind foot,	4	4	100°	50°	50°	60°	–	–	0.9	1.3	2.1	–	– –	– –	–	–	1.6	–	3.5	3.	2.2
	Fore foot,		4	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	1.1	–	0.25
Xiphopeza. 1. triplex,	Hind foot,	4	4	80°–90°	40°	50°	130°	–	–	0.8	1.5	1.1	–	– –	– –	–	–	0.5	–	2.6	7.	1.2
	Fore foot,		–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.9	–	–
Orthodactylus. 1. floriferus,	Hind foot,	4	5?	170°	45°	45°	–	45°	–	0.6	0.8	0.85	–	– –	– –	0.7	–	–	–	1.2	2.9–3.2	–
	Fore foot,		4	180°	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.5	–	–
2. intro-vergens,	Hind foot,	4	5	20°	–	–	–	–	–	1.	–	1.25	–	– –	– –	–	–	–	–	1.5	2.	–
	Fore foot,		4?	–	–	–	–	–	–	0.5	–	0.62	–	– –	– –	–	–	–	–	0.8	–	–
3. linearis,	Hind foot,	4	5?	20°	–	–	–	–	–	–	–	0.5	–	– –	– –	–	–	–	–	–	1.2–1.8	–
	Fore foot,		4	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–
Antipus. 1. flexiloquus,	Hind foot,	4	–	65°	–	–	–	–	–	0.8	1.	1.1	–	– –	– –	1.1	–	–	–	1.1	1.5–3.3	–
	Fore foot,		4	180°	–	–	–	–	–	0.6	0.8	0.65	–	– –	– –	0.6	0.4	–	–	0.9	–	–
2. bifidus,	Hind foot,	4	5	20°	–	–	–	–	–	12.	7.	–	–	– –	– –	–	–	–	–	1.2	–	–
	Fore foot,		2	15°	–	–	–	–	–	5.	12.	–	–	– –	– –	–	–	–	–	–	–	–
Stenodactylus. 1 curvatus,	Hind foot,	4	2	70°	–	–	–	–	–	0.7	0.8	1.	–	– –	– –	0.85	0.25	–	–	1.	3.3	–
	Fore foot,		5	–	–	–	–	–	–	0.25	0.3	0.5	–	– –	– –	0.55	0.1	–	–	–	–	–
Arachnichnus. 1. dehiscens,	Hind foot,	4	5	–	–	–	–	–	–	0.5	0.4	0.65	–	– –	– –	0.4	0.35	–	–	–	3–4.5	–
	Fore foot,		5	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–
Chimæra. 1. Barratti,	Hind foot,	4	4	180°	–	–	–	–	–	1.1	1.7	1.8	–	– –	– –	1.5	1.3	–	–	1.65	–	–
	Fore foot,		5	75°	37°	40°	65°	40°	–	1.2	2.5	3.8	–	– –	– –	2.7	–	–	–	6.9	18–20	3.
Isocampe. 1. strata,	Hind foot,	4	4	–	–	–	–	–	–	1.65	2.	2.3	–	– –	– –	2.15	–	–	–	–	3.4	–
	Fore foot,		4	35°	5°	50°	–	25°	–	1.1	1.7	1.2	–	– –	– –	1.1	–	–	–	–	–	–
Otozoum. 1. Moodii,	Hind foot,	4	5?	37°	25°	40°	–	11°	–	8.5	8.5	7.	2.7–2.	2.5–2.–2.2	– –	7.5	–	–	2.	1.9	30–51	4.3
	Fore foot,		4	–	–	–	–	–	–	3.	3.6	3.5	–	– –	– –	4.	–	2.5	–	–	–	–
Palamepus. 1. Clarki,	Hind foot,	4	5	67°	25°	30°	–	15°		5.4	6.5	8.6	–	– –	– –	6.	–	–	–	8.6	21.	–
	Fore foot,		4	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	3.5	–	–
Macropterna. 1. vulgaris,	Hind foot,	4	–	80°	30°	20°	–	30°	–	0.2	0.35	0.5	–	– –	– –	0.5	–	0.15	–	1.1	4.	0.6
	Fore foot,		4	–	–	–	–	–	–	0.25	0.35	0.30	–	– –	– –	0 25	–	–	–	–	–	0.15
2. divaricans,	Hind foot,	4	5	90°	20°	30°	–	40°	–	0.5	0.6	1.	–	– –	– –	0.6	–	–	–	2.8	3.3–7	1.8
	Fore foot,		4	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–
3. gracilipes,	Hind foot,	4	5	90°	40°	25°	–	25°	–	0.15	0.25	0.3	–	– –	– –	0.25	–	–	–	0.5	1.5–1.9	0.25
	Fore foot,		4	90°	40°	25°	–	25°	–	–	–	–	–	– –	– –	–	–	–	–	0.35	–	–
Cheirotheroides. 1. pilulatus,	Hind foot,	4	4	40°	10°	15°	–	15°	–	0.4	0.55	0.7	–	– –	– –	0.7	–	–	–	0.9	2.5	0.2
	Fore foot,		5	180°	–	–	–	–	–	0.15	0.3	0.35	–	– –	– –	0.25	0.15	–	–	0.45	–	–
Shepardia. 1. palmipes,	Hind foot,	4	5?	37°	10°	13°	–	14°	–	0 6	1.	1.2	–	– –	– –	0.9	–	–	–	1.2	–	–
	Fore foot,		5	105°	30°	25°	–	20°	30°	0.4	0 7	0.9	–	– –	– –	1.	0.4	–	–	1.	–	–

		DISTANCE. Of the middle front toe beyond the rest.	Between the tips of the outer toes in front.	Between the tips of the inner and second front toes.	Between the middle front and outer toe.	Between the middle front and hind toe.	Between the tracks of the hind and fore feet.	Of the heel from the line of direction.	VERSED SINE. Of the inner toe	Of the middle toe.	Of the outer toe.	Of the fourth toe.	WIDTH. Of the toes.	Of the heel.	Of the Trackway.	Of the caudal appendage.	Angle between the axis of the foot and the median line.	Number of phalangeal impressions reckoning outwards.
Harpedactylus. 1. gracilis,	Hind foot,	0 9	1.2	1.5	1.3	–	–	0.9	–	0.1	0.15	0.15	0.15–0.25	0.2	5.	–	2°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Xiphopeza. 1. triplex,	Hind foot,	–	1.5	1.	1.1	2.8	0.6	1.1	–	–	–	–	0.16	0.45–0.2	4.5	–	2°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Orthodactylus. 1. floriferus,	Hind foot,	–	0.5	–	–	–	–	3.9	–	–	–	–	–	–	3.25	–	35°–40°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. intro-vergens,	Hind foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	3.5	–	0°–6°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. linearis,	Hind foot,	–	–	–	–	–	–	0.2–0.5	–	–	–	–	–	–	1.5	–	20°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Antipus. 1. flexiloquus,	Hind foot,	–	–	1.	–	–	–	–	–	–	–	–	–	–	5.	–	20°	–
	Fore foot,	–	–	–	–	–	–	1.2	–	–	–	–	–	–	–	–	50°–70°	–
2. bifidus,	Hind foot,	–	–	–	–	–	8.	–	–	–	–	–	1.25	–	1.1	–	–	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	1.25	–	–	–	–	–
Stenodactylus. 1 curvatus,	Hind foot,	–	–	–	–	–	–	0 6	0.1	0.15	0.18	0.1	–	–	2 5	–	20°	–
	Fore foot,	–	–	–	–	–	–	0.6–1.1	–	–	–	–	–	–	–	–	85°	–
Arachnichnus. 1. dehiscens,	Hind foot,	–	–	–	–	–	2.3	–	–	–	–	–	–	–	3.	–	0°–3°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chimæra. 1. Barratti,	Hind foot,	–	0.7	0.7	1.	1.4	–	–	–	–	–	–	–	–	–	–	–	–
	Fore foot,	1.75	3.3	2.3	2.3	4.	–	–	–	–	–	–	–	–	9.	1.	15°–25°	–
Isocampe. 1. strata,	Hind foot,	–	–	–	–	–	–	2.2–3.2	0.25	0.3	0.4	0.15	–	–	7.0	0.25-0.6	–	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Otozoum. 1. Moodii,	Hind foot,	–	–	–	–	–	–	2.5	–	–	–	–	2.2–3	4.	–	–	10°	3-3-3-4
	Fore foot,	–	–	–	–	–	–	–	1.	–	–	–	–	–	26.5	–	–	–
Palamepus. 1. Clarki,	Hind foot,	–	–	2.5	3.3	3.	–	–	–	–	–	–	–	1.8–2.1	5.	–	2°–4°	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Macropterna. 1. vulgaris,	Hind foot,	–	–	–	–	–	–	0.4	–	–	–	–	–	–	2.	–	10°–20°	–
	Fore foot,	–	–	–	–	–	–	0.12	–	–	–	–	–	–	–	–	–	–
2. divaricans,	Hind foot,	–	0.4	0.65	0 65	0.5	–	0.1	–	–	–	–	–	0.45	3.	–	–	–
	Fore foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. gracilipes,	Hind foot,	–	–	–	–	–	–	0.3	–	–	–	–	–	–	1.2	–	–	–
	Fore foot,	–	–	–	–	0.5	–	–	–	–	–	–	–	–	–	–	–	–
Cheirotheroides. 1. pilulatus,	Hind foot,	–	–	–	–	–	–	–	–	–	–	–	–	–	2 25	–	20°–30	–
	Fore foot,	–	–	–	–	–	1.8	–	–	–	–	–	–	–	–	–	85°	–
Shepardia. 1. palmipes,	Hind foot,	–	–	–	–	–	–	–	–	–	–	–	–	0.15	–	–	–	–
	Fore foot,	–	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

A TABULAR VIEW—Continued.

			DIVARICATION.						LENGTH.													DISTANCE.							VERSED SINE.				WIDTH.					
	Number of feet.	Number of toes.	Of the outer front toes.	Of the inner and second front toes.	Of the second and third front toes.	Of the hind toe and middle front toe.	Of the third and fourth front toes.	Of the fourth and fifth front toes.	Of the inner toe.	Of the second toe.	Of the third toe.	Of the phalangeal impressions of the inner toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the second toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the third toe, beginning with the proximal phalanx.	Of the fourth front toe.	Of the fifth front toe.	Of the hind toe.	Of the claw of the middle toe.	Of the foot.	Of the step.	Of the heel.	Of the middle front toe beyond the rest.	Between the tips of the outer toes in front.	Between the tips of the inner and second front toes.	Between the middle front and outer toe.	Between the middle front and hind toe.	Between the tracks of the hind and fore feet.	Of the heel from the line of direction.	Of the inner toe.	Of the middle toe.	Of the outer toe.	Of the fourth toe.	Of the toes.	Of the heel.	Of the Trackway.	Of the caudal appendage.	Angle between the axis of the foot and the median line.	Number of phalangeal impressions reckoning outwards.
Laguncupales.																																						
1. latens, Hind foot,	4	4	180°	50°	70°	–	65°	–	0.5	0.55	0.8	–	–	–	0.6	–	–	–	0.85	4.1–5.1	–	–	0.5	0.9	0.75	–	–	–	–	–	–	–	0.2	–	3.	–	–	–
Fore foot,		4	180°	50°	70°	–	65°	–	0.5	0.55	0.8	–	–	–	0.6	–	–	–	–	–	–	–	0.5	0.9	0.75	–	–	1.25	–	–	–	–	–	–	–	–	–	–
Selenichnus.																																						
1. falcatus,	2	3	–	–	–	–	–	–	1.4	2.8	2.2	–	–	–	–	–	–	–	2.6	6.5	–	–	–	–	–	–	–	–	–	0.25	–	–	–	–	2.5	0.2	10°–20°	–
2. breviusculus,*	4	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	3–4.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5	0.1	0°–10°	–
Hoplichnus.																																						
1. equus, Hind foot,	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.3	40–48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.7	–	–	–
Fore foot,		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. poledrus, Hind foot,	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.6	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.	–	–	–
Fore foot,		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Saltator.																																						
1. bipedatus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	1.25	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–	0.3	–	–	–
2. caudatus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8–1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	–	–	–
Ancyropus.																																						
1. heteroclitus, Hind foot,	4	5?	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	2.	4.5–5.5	–	–	–	–	–	–	–	–	0.4–0.7	–	–	–	–	0.7	6.5	–	2°–4°	–
Fore foot,		5?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.	–	–	–	–	–	–	–	–	–	0.4–0·7	–	–	–	–	0.3	–	–	0°	–
Chelonoides.																																						
1. incedens, Hind foot,	4	4?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.5	–	–	–
Fore foot,		5	100°	–	–	–	–	–	0.4	0.7	0.9	–	–	–	0.8	0.8	–	–	1.7	1.4	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1°	–
Helcura.																																						
1. caudata,	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5.	–	–	–
2. surgens,	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4.5–6.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.	–	–	–
3. anguinea,	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5–6?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.	–	–	–
Exocampe.																																						
1. arcta, Hind foot,	4	4	110°	–	–	–	–	–	0.8	1.1	1.3	–	–	–	1.3	–	–	–	1.9	8.5	0.8	–	–	–	–	–	–	1.	–	–	0.25	–	–	–	3.	–	–	–
Fore foot,		5	110°	–	–	–	–	–	0.35	0.9	0.1	–	–	–	1.	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. ornata, Hind foot,	4	4	100°	–	–	–	–	–	0.22	0.3	0.4	–	–	–	0.32	–	–	–	–	4.	–	–	–	–	–	–	–	0.3–0.7	–	–	–	–	0.9	–	1.	–	15°–25°	–
Fore foot,		5	130°	–	–	–	–	–	0.3	0.3	0.3	–	–	–	0.3	0.3	–	–	0.5	–	–	–	–	–	–	–	0.25	–	–	–	–	–	–	–	–	–	40°–10°	–
Amblypus.																																						
1. dextratus,	4	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.	4–4.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4.	–	–	–
Ptilichnus.																																						
1. anomalus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5.3	–	–	–
2. typographus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. pectinatus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5	–	–	–
4. hydrodromus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9	–	–	–
Harpagopus.																																						
1. hudsonius,	–	2	40°	–	–	–	–	–	2–3.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7	–	–	–
2. dubius,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.25	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–
Stratipes.																																						
1. latus,	–	–	–	–	–	–	–	–	3–4.	–	–	–	–	–	–	–	–	–	–	9–13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.7	–	–	–
Hamipes.																																						
1. didactylus,	–	2	–	–	–	–	–	–	0.5	0.5	–	–	–	–	–	–	–	–	0.42	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.62	–	–	–
Acanthichnus.																																						
1. cursorius,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1–0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.18	–	–	–
2. saltatorius,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.08	0.8–0.18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–
3. tardigradus,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.15	0.1–2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.48	–	15°–20°	–
Conopsoides.																																						
1. larvalis,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3–0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	–	15°–40°	–

*Number of feet and toes corrected from a specimen just found, (October 20, 1858.)

A TABULAR VIEW—Continued.

			DIVARICATION.						LENGTH.													DISTANCE.							VERSED SINE.				WIDTH.					
	Number of feet.	Number of toes.	Of the outer front toes.	Of the inner and second front toes.	Of the second and third front toes.	Of the hind toe and middle front toe.	Of the third and fourth front toes.	Of the fourth and fifth front toes.	Of the inner toe.	Of the second toe.	Of the third toe.	Of the phalangeal impressions of the inner toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the second toe, beginning with the proximal phalanx.	Of the phalangeal impressions of the third toe, beginning with the proximal phalanx.	Of the fourth front toe.	Of the fifth front toe.	Of the hind toe.	Of the claw of the middle toe.	Of the foot.	Of the step.	Of the heel.	Of the middle front toe beyond the rest.	Between the tips of the outer toes in front.	Between the tips of the inner and second front toes.	Between the middle front and outer toe.	Between the middle front and hind toe.	Between the tracks of the hind and fore feet.	Of the heel from the line of direction.	Of the inner toe.	Of the middle toe.	Of the outer toe.	Of the fourth toe.	Of the toes.	Of the heel.	Of the Trackway.	Of the caudal appendage.	Angle between the axis of the foot and the median line.	Number of phalangeal impressions reckoning outwards.
Bifurculapes.																																						
1. laqueatus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	–	–	–
2. tuberculatus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.15	0.25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–
3. elachistotatus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.05	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–	20°–35°	–
4. scolopendroideus,	–	–	25°–30°	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.45-0.25	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9	–	5°–20°	–
Grammepus.																																						
1. erismatus,	–		30°	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.5	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.2	–	0°	–
2. unordinatus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
Lithographus.																																						
1. hieroglyphicus,	6	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.2	0.3-0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	–	–	–
2. cruscularis,	6	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.35	–	–	–
Hexapodichnus.																																						
1. magnus,	6	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.2	0.25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	–	–	–
2. horrens,	6	–	40°	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	0.1	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	–	–	–
Copeza.																																						
1. triremis,	6	–	–	–	–	–	–	–	0.1	0.07	–	–	– –	– –	–	–	–	–	0.1	0.44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.4	–	20°	–
Unisulcus.																																						
1. Marshi,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
2. intermedius,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–
3. minutus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.05	–	–	–
Cochlichnus.																																						
1. anguineus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1–0.35	–	–	–	0.33	–	–	–
Cochlea.																																						
1. Archimedea,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
Halysichnus.																																						
1. laqueatus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	0.52	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–
2. tardigradus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.05	–	–	–
Cunicularius.																																						
1. retrahens,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2–0.4	–	–	–
Sphærapus.																																						
1. larvalis,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
2. magnus,	–	–	–	–	–	–	–	–	–	–	–	–	– –	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.55	–	–	–

GLOSSARY

OF NEW OR UNUSUAL TERMS USED IN THE PRECEDING REPORT.

Annelids: naked worms, like the leach, earthworm, &c.

Batrachians: animals of the frog and salamander tribes.

Batrachoid: having the appearance or some characters of a batrachian.

Calcigrade: when an animal's heel in walking sinks deeper than the rest of the foot.

Caudate: having a tail.

Chelonians: animals of the tortoise kind.

Crustaceans: animals of the lobster and crab kind.

Cunoid: having the appearance or some characters of a dog.

Didactylous: having two toes.

Digitigrade: when in walking an animal rests chiefly on its toes.

Divarication: the spread or opening.

Fauna: the animals of a district or country.

Heterocercal: having unequal lobes to the tail.

Homocercal: having equal lobes in the tail.

Ichnological: relating to tracks.

Ichnolithology: the science of fossil footmarks.

Ichnology: the science of tracks in general.

Ichno-geological Map: a geological map showing the localities of fossil footmarks upon it.

Insects: animals with six legs and mostly with wings.

Lacertilian: of or belonging to lizards.

Lacertiloid: having the appearance or some character of a lizard.

Leptodactylous: having narrow or slender toes.

Lithichnozoa: stone-track animals: or animals made known by their tracks in stone.

Lizards: four-footed caudate animals, with a scaly covering.

Loricoid: resembling or having some character of the scaly lizards.

Marsupialoid: resembling the Marsupial or pouched animals.

Myriapods: animals of the centipede and millipede families.

Ornithic: of, or relating to birds.

Ornithichnites: fossil bird's tracks.

Ornithoid: having the appearance or some character of a bird.

Pachydactylous: thick-toed.

Palmigrade: that walks on the whole foot.

Pentedactylous: having five toes.

Phalanx: the bone between two joints of the fingers or toes.

Sauroidichnites: like the tracks of Saurians.

Tetradactylous: having four toes.

Trackway: the belt of surface impressed by the body and extremities of the animal.

Tridactylous: having three toes.

DESCRIPTION OF THE PLATES.

PLATE I.

Sketch of the Moody Footmark Quarry, South Hadley.

PLATE II.

Ichno-Geological Map of the Connecticut Valley.

PLATE III.

Sections across the Valley.

PLATE IV.

Fig. 1. Sketch of the Appleton Cabinet—external view.
2. Sketch of the interior of the Ichnological Cabinet or Gallery.

PLATE V.

Fig. 1. Sketch of the radiating fronds of Clathropteris.
2. View of a Shell in Sandstone.

PLATE VI.

Fig. 1. Manner in which the toes bend down the strata.
2. Track passing obliquely through the strata.
3. Foot of Palapteryx ingens.
4 and 5. Feet of the Iguana.
6. Foot of the Coot.
7. Tracks of the Banded Proteus.
8. Track of Fringilla.
9. Outline of a three-toed lizard.
10. Phyllurus Cuvieri.
11. Dactylura Capensis.
12. Salamandra Beechyi.
13. Foot of Ornithorhynchus.

PLATE VII.

Fig. 1. Frond of Clathropteris, natural size.
2. Cone and Fronds from sandstone.
3. Mormolucoides articulatus, natural size.
Fig. 4. Mormolucoides articulatus, enlarged slightly.
5. Tracks of a Mink?
6. " of a Muskrat.
7. " of a Dog.
8. " of a Partridge.
9. " of a Mouse.
10. " of a Tortoise.
11. " of a Goose.
12. " of a Hen.
13. " of a Pea Hen.
14. " of a Turkey.
15. " of a Quail?
16. " of a Wharf Rat.
17. " of a Crow.
18. " of a Mink.
19. " of a Muskrat.
20. Foot of a Plover.
21. " of a Tringa.
22. " of Tetrao lagopus.
23. " of Hypsiprimnus pencillatum.
24. " of Perameles obesula.
25. " of Lacerta lemniscata.
26. " of Lacerta agilis.
27. " of the Stork.
28. " of Ardea Herodias.
29. " of Ardea pavonina.
30. " of the New Holland Ostrich.
31. " of Ardea cœrulea.
32. " of Charadius Wilsonius.
33. Tracks of an Insect Larva.

PLATE VIII.

Outline of the Tracks of Anomœpus major, natural size.

PLATE IX.

Fig. 1. Tracks of Anomœpus minor, natural size.
2. " of Anomœpus minor, one-third natural size, hind and fore foot.

Fig. 3. Tracks of Anisopus Deweyanus, natural size.
4. " of Anisopus gracilis, "
5. " of Cunichnoides marsupialoideus, natural size.

PLATE X.

Outline of the Foot or Track of Brontozoum giganteum, of the natural size.

PLATE XI.

Fig. 1. Foot of Brontozoum minusculum, natural size.
" of Brontozoum tuberatum, "

PLATE XII.

Fig. 1. Foot of Brontozoum exsertum, natural size.
2. " of Brontozoum validum, "
3. " of Brontozoum Sillimanium, "
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PLATE XIII.

Fig. 1. Foot of Amblonyx giganteus, natural size.
2. " of Amblonyx Lyellianus, "
3. " of Grallator cursorius, "
4. " of Grallator tenuis, "
5. " of Grallator gracillimus, "
6. " of Grallator cuneatus, "

PLATE XIV.

Fig. 1. Foot of Argozoum Redfieldianum, natural size.
2. " of Argozoum dispari-digitatum, "
3. " of Argozoum pari-digitatum, "
4. " of Platypterna Deaniana, "
5. " of Platypterna tenuis, "
6. " of Platypterna delicatula, "
7. " of Platypterna recta, "
8. " of Platypterna varica, "
9. " of Platypterna digitigrada, "
10. " of Ornithopus gallinaceus, "
11. " of Ornithopus gracilior, "
12. " of Platypterna gracillima, "

PLATE XV.

Fig. 1. Foot of Tridentipes ingens, natural size.
2. " of Tridentipes elegans, "
3. " of Tridentipes elegantior, "
4. " of Tridentipes insignis, "
5. " of Tridentipes uncus, "

PLATE XVI.

Fig. 1. Foot of Gigantitherium caudatum, natural size.
2. " of Gigantitherium caudatum, with a trace of the tail sweeping to the right and left.

PLATE XVII.

Fig. 1. Foot of Gigantitherium minus, natural size.
2. " of Hyphepus Fieldi, natural size, with a plumose trail trace.
3. " of Corvipes lacertoideus, natural size.
4. " of Tarsodactylus caudatus "
5. " of Apatichnus circumagens, "
6. " of Apatichnus bellus, "
7. " of Plesiornis quadrupes, "
8. " of Plesiornis pilulatus, "
9. " of Typopus abnormis, "
10. " of Typopus gracilis, "

PLATE XVIII.

Fig. 1. Foot of Polemarchus gigas, natural size.
2. " of Plectropterna minitans, "
3. " of Plectropterna gracilis, "
4. " of Plectropterna angusta, "
5. " of Plectropterna lineans, "

PLATE XIX.

Fig. 1. Hind foot of Triænopus leptodactylus, natural size.
2. Fore foot of Triænopus leptodactylus, natural size.
Figs. 3, 4 and 5, Track of Plectropterna minitans on successive layers of stone.
6, 7, 8 and 9, " of Triænopus leptodactylus on successive layers.
10, 11 and 12, " of Plectropterna minitans on successive layers.

PLATE XX.

Figs. 1, 2 and 3. Track of Triænopus leptodactylus on successive layers.
Fig. 4. Foot or Track of Harpedactylus gracilis, hind and fore feet, natural size.
5. Feet of Isocampe strata, natural size.
6. " of Xiphopera triplex, natural size.
7. " of Orthodactylus floriferus, natural size.

Fig. 8. Foot of Orthodactylus intro-vergens, natural size.
9. Feet of Orthodactylus linearis, natural size.
10. " of Antipus flexiloquus, "
11. " of Stenodactylus cuneatus, natural size.
12. " of Arachnichnus detriscens, "
13. Single track of Arachnichnus dehiscens, with mud veins, natural size.

PLATE XXI.

Fig. 1. Hind foot of Chimæra Barratti, natural size.
2. Fore foot of Chimæra Barratti, "
3. Fore foot? of Chimæra Barratti, "
4. Hind foot of Chimæra Barratti on a layer below the one on which the animal trod.
5. Mud Nests of Batrachoides nidificans, natural size.
6. " of Batrachoides antiquior, natural size.
7. " of Living Tadpoles, natural size.

PLATE XXII.

Hind foot of Otozoum Moodii, natural size.

PLATE XXIII.

Fig. 1. Fore foot of Otozoum Moodii, natural size.
2. Hind foot of Palamepus Clarki, "
3. Feet of Cheirotheroides pilulatus, natural size.
4. " " " "
5. " of Macropterna vulgaris, "
6. " of Macropterna gracilipes "
7. " of Macropterna divaricans, "
8. " of Selenichnus falcatus, with trace of the tail, natural size.
9. " of Selenichnus breviusculus, with trace of the tail, natural size.

PLATE XXIV.

Fig. 1. Foot of Lagunculapes latus, natural size.
2. Feet of Shepardia palmipes, "
3. Fore foot of Hoplichnus equus, "
4. Hind foot of Hoplichnus equus, "
5. Outline sketch of Tracks of Hoplichnus equus, reduced.
6. Fore foot of Hoplichnus poledrus, natural size.
7. Hind foot of Hoplichnus poledrus, "
8. Tracks of Saltator bipedatus, natural size.
9. " of Saltator caudatus, "
10. " of Saltator caudatus, "

PLATE XXV.

Fig. 1. Tracks of Ptilichnus anomalus, natural size.
2. Tracks of Ptilichnus anomalus, natural size, with a row of indentations.
3. Hind foot of Ancyropus heteroclitus, natural size.
4. Fore foot of Ancyropus heteroclitus, natural size.
5. Hind foot of Exocampe (by mistake spelt Hectocampe) arcta, natural size.
6. Fore foot (?) of Exocampe (by mistake spelt Hectocampe) arcta, natural size.
7. Hind foot (?) of Amblypus dextratus, natural size.
8. Foot of Hamipes didactylus, natural size.
9. Impressions of Ptilichnus pectinatus, natural size.
10. Foot of Exocampe arcta, natural size.
11. Feet of Exocampe (by mistake spelt Hectocampe) ornata, natural size.

PLATE XXVI.

Fig. 1. Trackway of Unisulcus Marshi, natural size.
2. Trackway of Unisulcus intermedius, natural size.
3. Trackway of Unisulcus minutus, natural size.
4. Cunicularius retrahens, natural size.
5. Trails of Ptilichnus hydrodomus, natural size.
6. Trackway of Cochlichnus anguineus, natural size.
7. Trackway of Halysichnus laqueatus, natural size.
8. Trackway of Halysichnus tardigradus, natural size.
9. Trackway of Cochlea Archimedea, natural size.

PLATE XXVII.

Fig. 1. Tracks of Bifurculapes scolopendroideus, natural size.
2. Tracks of Lithographus hieroglyphicus, natural size.

PLATE XXVIII.

Fig. 1. Tracks of Acanthichnus tardigradus and cursorius, Bifurculapes tuberculatus, and Cochlichnus anguineus, natural size.
2. Tracks of Sphærapus larvalis, natural size.
3. Tracks of Sphærapus magnus, natural size.
Figs. 4 and 5. Tracks of Acanthichnus saltatorius, natural size.

PLATE XXIX.

Fig. 1. Tracks of Grammepus erismatus, natural size.
2. Tracks of Grammepus unordinatus, natural size.
3. Tracks of Lithographus hieroglyphicus, natural size.
4. Tracks of Lithographus cruscularis, Bifurculapes elachistotatus, and a Coniferous Plant, natural size.
5. Ambrotype sketch of small fossil Plants.
6. Tracks of Conopsoides larvalis, natural size.
7. Tracks of Hexapodichnus magnus, natural size.

PLATE XXX.

Fig. 1. Tracks of Hexapodichnus horrens and Bifurculapes laqueatus, natural size.
2. Tracks of Bifurculapes laqueatus and Conopsoides larvalis, natural size.
3. Tracks of Lithographicus cruscularis and Bifurculapes laqueatus and elachistotatus, natural size.
4. Tracks of Bifurculapes tuberculatus and Conopsoides larvalis, natural size.

PLATE XXXI.

Fig. 1. Tracks of Acanthichnus cursorius, with a coniferous plant and seeds, natural size.
2. Tracks of a snipe on clay with rain drops, natural size.
3. Tracks of Chelonoides incedens, natural size.
4. Tracks of Copeza triremis, natural size.

PLATE XXXII.

Fig. 1. Tracks of a Boy and a Bird with rain drops on clay, natural size.
Fig. 2. Tracks of a Bird and a Frog on clay, natural size.

PLATE XXXIII.

Fig. 1. Reduced outline of seven tracks of Brontozoum giganteum.
2. Reduced outline of three tracks of the same.
3. Reduced outline of three tracks with several smaller tracks of other species of Brontozoum.
4. Reduced outline of eleven tracks of the hind foot of Otozoum Moodii, with many others of Brontozoum.
5. Reduced outline of nine tracks of Otozoum Moodii in relief with many others of Brontozoum.

PLATE XXXIV.

Fig. 1. Row of outline tracks of Macropterna gracilipes, natural size.
2. Outline of numerous tracks of Anomœpus minor, reduced.
3. Outline of a row of the tracks of Stenodactylus curvatus, natural size.

PLATE XXXV.

Figs. 1 and 2. Reduced outline rows of the tracks of Plesiornis quadrupes.
Fig. 3. Reduced outline row of the tracks of Tridentipes uncus.
4. Reduced outline row of the tracks of Argozoum pari-digitatum.
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3. Reduced outline row of the tracks of Plectropterna angusta.

4. Reduced outline row of the tracks of Plesiornis pilulatus.

5. Reduced outline row of the tracks of Isocampe strata.

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2. Ambrotype sketch of a slab No. $\frac{1}{1}$, with Anomœpus, Amblonyx, and Brontozoum.

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Fig. 1. Ambrotype sketch of slab No. $\frac{25}{1}$, with Grallator cuneatus and formosus, Argozoum pari-digitatum and Brontozoum.

Fig. 2. Ambrotype sketch of slab No. $\frac{19}{4}$, with Brontozoum gracillimum, and rain drops.

3. Ambrotype sketch of slab No. $\frac{30}{1}$, with Brontozoum exsertum, &c.

4. Ambrotype sketch of slab No. $\frac{5}{9}$, with Brontosoum exsertum, &c.

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Fig. 1. Ambrotype sketch of slab No. $\frac{26}{10}$, with rows of Brontozoum isodactylum and tortoise trails.

2. Ambrotype sketch of slab No. $\frac{16}{1}$, with Brontozoum minusculum, &c.

3. Ambrotype sketch of slab No. $\frac{16}{6}$, with Brontozoum exsertum, &c.

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Fig. 1. Ambrotype sketch of slab No. $\frac{17}{1}$, with Brontozoum giganteum, and minusculum and Grallator cuneatus.

2. Ambrotype sketch of slab No. $\frac{20}{6}$, with Brontozoum, Grallator, Gigantitherium, Hyphepus and Anisopus.

PLATE XLII.

Fig. 1. Ambrotype sketch of slab No. $\frac{29}{1}$, with Brontozoum, Grallator, Apatichnus and Anisopus.

2. Ambrotype sketch of slab No. $\frac{1}{3}$, with Gigantitherium, Hyphepus, Grallator, Brontozoum, Anisopus and Saltator.

3. Ambrotype sketch of slab No. $\frac{14}{4}$, with Brontozoum minusculum, Grallator cuneatus, and Anisopus gracilis.

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3. Ambrotype sketch of slab No. $\frac{38}{16}$, with Anisopus gracilis.

4. Ambrotype sketch of slab No. $\frac{26}{8}$, with Anisopus gracilis.

5. Ambrotype sketch of slab No. $\frac{26}{7}$, with Anisopus gracilis.

Fig. 6. Ambrotype sketch of slab No. $\frac{26}{18}$, with Brontozoum Sillimanium.

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Fig. 1. Ambrotype sketch of slab No. $\frac{19}{14}$, with Anomœpus minor.

2. Ambrotype sketch of No. $\frac{12}{1}$, with tracks of Palamepus Clarki, and Brontozoum.

3. Ambrotype sketch of slab No. $\frac{16}{5}$, with Anomœpus minor and Brontozoum.

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5. Ambrotype sketch of slab No. $\frac{20}{1}$, with two caudal impressions of Anomœpus major, Brontozoum, &c.

6. Ambrotype sketch of slab No. $\frac{30}{2}$, with Gigantitherium caudatum and minus, Grallator cuneatus, Hyphepus Fieldi, &c.

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Fig. 1. Ambrotype sketch of slab No. $\frac{19}{9}$, with Helcura caudata, Tridentipes gracilior, &c.

2. Ambrotype sketch of slab No. $\frac{6}{1}$, with Orthodactylus floriferus.

3. Ambrotype sketch of slab No. $\frac{5}{11}$, with Tridentipes insignis.

4. Ambrotype sketch of slab No. $\frac{33}{29}$, with Lagunculapes latus.

5. Ambrotype sketch of slab No. $\frac{20}{7}$. Tracks of Plesiornis quadrupes, Brontozoum.

6. Ambrotype sketch of slab No. $\frac{26}{21}$, with Apatichnus bellus and Tridentipes elegans.

7. Ambrotype sketch of slab No. $\frac{19}{1}$, with Typopus abnormis.

8. Ambrotype sketch of slab No. $\frac{31}{27}$, with Triænopus leptodactylus.

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2. Ambrotype sketch of slab No. $\frac{4}{4}$, showing the web of Otozoum Moodii.

3. Ambrotype sketch of slab No. $\frac{6}{3}$, with Brontozoum isodactylum and Otozoum.

Fig. 4. Ambrotype sketch of slab No. $\frac{5}{8}$, with Apatichnus circumagens.

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2. Ambrotype sketch of slab No. $\frac{1}{4}$, with Tridentipes insignis.

3. Ambrotype sketch of slab No. $\frac{6}{2}$, with Platypterna recta.

4. Ambrotype sketch of slab No. $\frac{11}{1}$, with Platypterna varica.

5. Ambrotype sketch of slab No. $\frac{25}{2}$, with Grallator cuneatus, and Brontozoum minusculum validum and Sillimanium.

6. Ambrotype sketch of slab No. $\frac{13}{2}$, with Argozoum pari-digitatum.

PLATE XLVIII.

Fig. 1. Ambrotype sketch of slab No. $\frac{26}{9}$, with Exocampe ornata.

2. Ambrotype sketch of slab No. $\frac{34}{9}$, with Plectropterna gracilis.

3. Ambrotype sketch of slab No. $\frac{41}{25}$, with Macropterna divaricans.

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5. Ambrotype sketch of slab No. $\frac{34}{17}$ with Amblypus dextratus.

6. Ambrotype sketch of slab No. $\frac{41}{39}$, with Exocampe ornata.

7. Ambrotype sketch of slab No. $\frac{35}{32}$, with Macropterna vulgaris.

8. Ambrotype sketch of slab No. $\frac{35}{25}$, with Antipus flexiloquus.

9. Ambrotype sketch of slab No. $\frac{36}{1}$, with Hoplichnus poledrus.

10. Ambrotype sketch of slab No. $\frac{23}{2}$, with Antipus bifidus.

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Fig. 1. Ambrotype sketch of slab No. $\frac{19}{12}$, with the trackway of Unisulcus Marshi.

Fig. 2. Ambrotype sketch of slab No. $\frac{19}{10}$, with Unisulcus minutus.

3. Ambrotype sketch of slab No. $\frac{40}{1}$, with Macropterna vulgaris.

4. Ambrotype sketch of slab No. $\frac{13}{4}$, with Stratipes latus.

5. Ambrotype sketch of slab No. $\frac{41}{20}$, with Exocampe arcta.

6. Ambrotype sketch of slab No. $\frac{10}{2}$, with Harpagopus Hudsonius.

7. Ambrotype sketch of slab No. $\frac{36}{49}$, with Cochlea Archimedea.

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4. Ambrotype sketch of slab No. $\frac{38}{9}$, with mud nests of recent Tadpoles.

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2. Ambrotype sketch of the Stony Volume No. $\frac{27}{11}$, with Xiphopeza triplex.

3. Ambrotype sketch of the Stony Volume No. $\frac{27}{1}$, with Macropterna vulgaris.

Fig. 4. Ambrotype sketch of the Stony Volume No. $\frac{27}{10}$, with Xiphopeza triplex.

5. Ambrotype sketch of the Stony Volume No. $\frac{27}{18}$, with Harpedactylus gracilis.

6. Ambrotype sketch of the Stony Volume No. $\frac{27}{4}$, with Platypterna varica; a book with five leaves.

7. Ambrotype sketch of the Stony Volume No. $\frac{27}{11}$, with Brontozoum tuberatum.

8. Ambrotype sketch of the Stony Volume No. $\frac{18}{2}$, with Tridentipes elegans; the fourth page of a book with two leaves.

9. Ambrotype sketch of the Stony Volume No. $\frac{18}{2}$, with Tridentipes elegans; second page.

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3. Ambrotype sketch of the two-leaved Stony Volume No. $\frac{27}{14}$, with Xiphopheza triplex.

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5. Ambrotype sketch of the two-leaved Stony Volume No. $\frac{12}{3}$, with Grallator tenuis and Apatichnus.

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7. Ambrotype sketch of the stony two-leaved Volume No. $\frac{28}{1}$, with two pages of Brontozoum giganteum.

8. Ambrotype sketch of the stony two-leaved Volume No. $\frac{26}{5}$, with two pages of Anisopus Deweyanus.

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5. Ambrotype sketch of a reduced track of Amblonyx giganteus.

6. Ambrotype sketch of a reduced track of Amblonyx Lyellianus.

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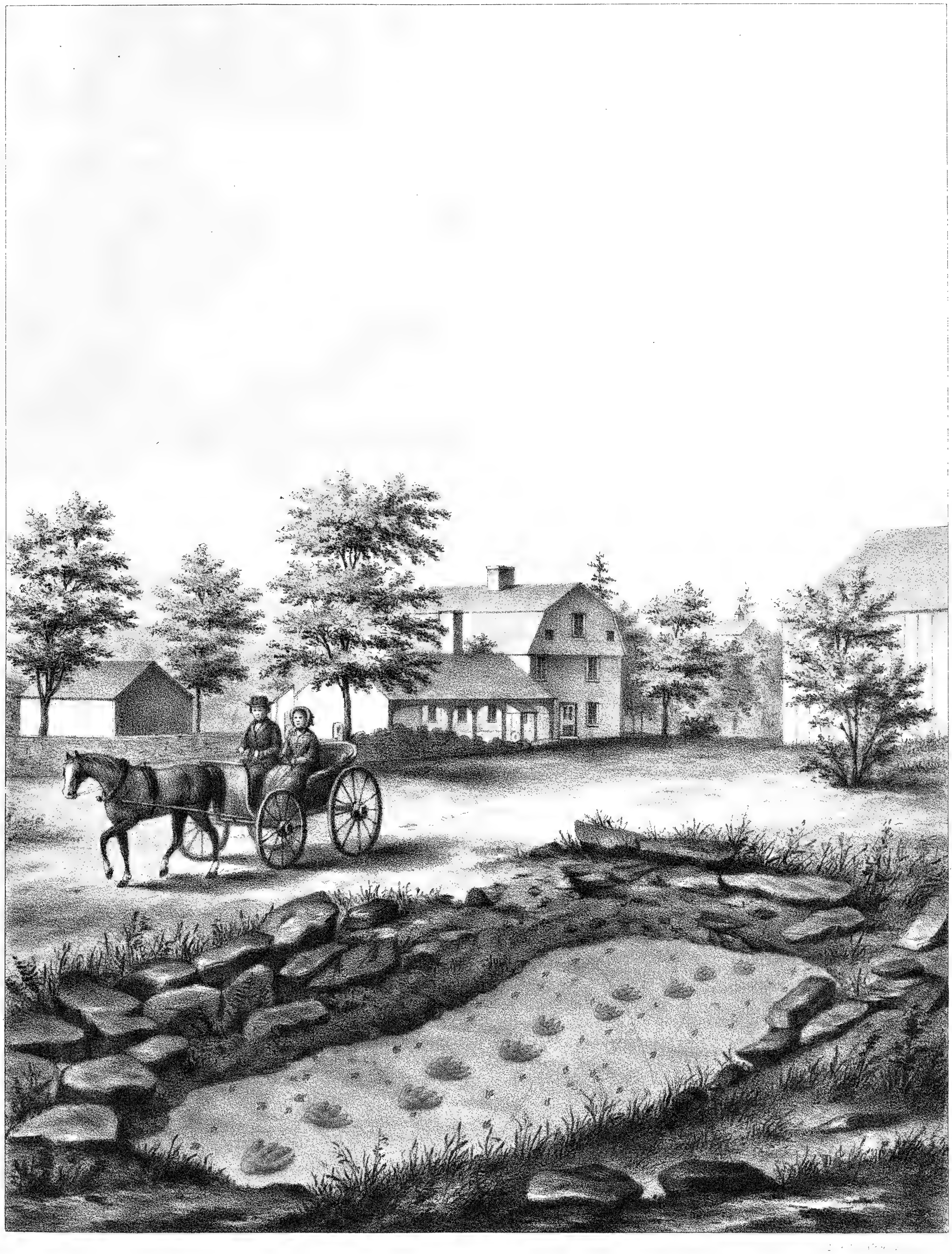


THE MOODY FOOT MARK QUARRY, SOUTH HADLEY


ICHNOGEOLOGICAL MAP OF THE CONNECTICUT VALLEY.
1857.
Sandstone
Trap
Volcanic Grit
Liassic Limestone
Encrinal Limestone
Hypozoic Rocks
Footmarks
Course of Strata
WARWICK
ORANGE
NEW SALEM
PELHAM PRESCOTT
BELCHERTOWN
MONSON
WILBRAHAM
STAFFORD
TOLLAND
VERNON
BOLTON
MANCHESTER
EAST HARTFORD
GLASTENBURY
MARLBORO
CHATHAM
EAST HADDAM
HADDAM
KILLINGWORTH
NORTHFIELD
ERVING
WENDELL
SHUTESBURY
EVERETT
AMHERST
GRANBY
SOMERS
ELLINGTON
EAST WINDSOR
PORTLAND
MIDDLETOWN
DURHAM
GUILFORD
BERNARDSTON
MONTAGUE
SUNDERLAND
HADLEY
SOUTH HADLEY
CHICOPEE
SPRINGFIELD
LONGMEADOW
ENFIELD
MASSACHUSETTS
CONNECTICUT
Connecticut River
GREENFIELD
DEERFIELD
WHATELY
HATFIELD
NORTHAMPTON
EAST HAMPTON
HOLYOKE
WEST SPRINGFIELD
SUFFIELD
WINDSOR
HARTFORD
WETHERSFIELD
CROMWELL
MERIDEN
WALLINGFORD
NORTH BRANFORD
BRANFORD
EAST HAVEN
NORTH HAVEN
SHELBURNE
CONWAY
WILLIAMSBURG
WEST HAMPTON
SOUTH HAMPTON
MONTGOMERY
WESTFIELD
RUSSELL
SOUTHWICK
GRANVILLE
GRANBY
SIMSBURY
BLOOMFIELD
AVON
FARMINGTON
BERLIN
SOUTHINGTON
CHESHIRE
NEW HAVEN
ORANGE
Turners Falls Section
Springfield Section
Farmington River
Deerfield River
Fish.
Bones.
10 Miles.
WEST.
EAST.
Horizontal Scale 200 rods to the inch
Vertical Scale 250 feet to the inch
Middle Tekoa.
SPRINGFIELD SECTION
Westfield.
Trap Range.
Connecticut River.
Chicopee Falls.
Chicopee Falls.
Reptile Bones.
Indian Orchard.
Wilbraham Railroad Station.

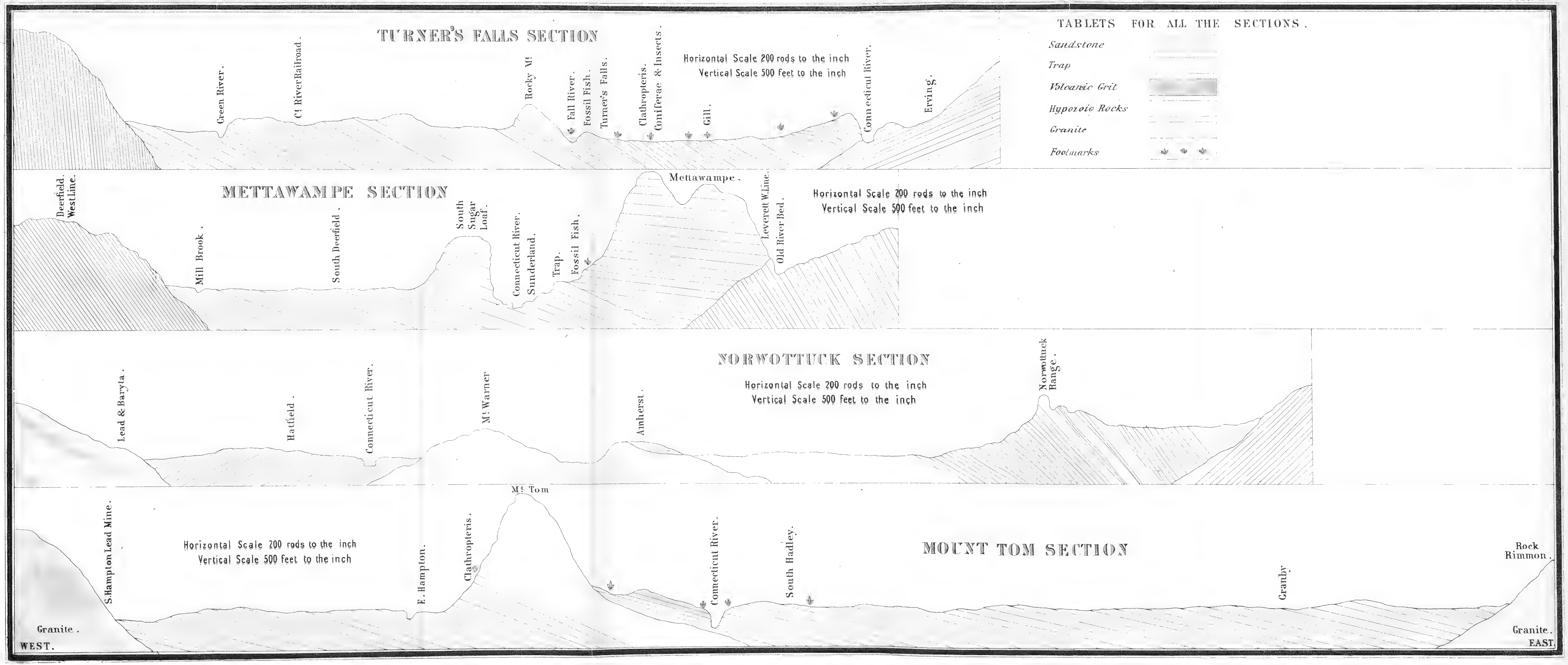
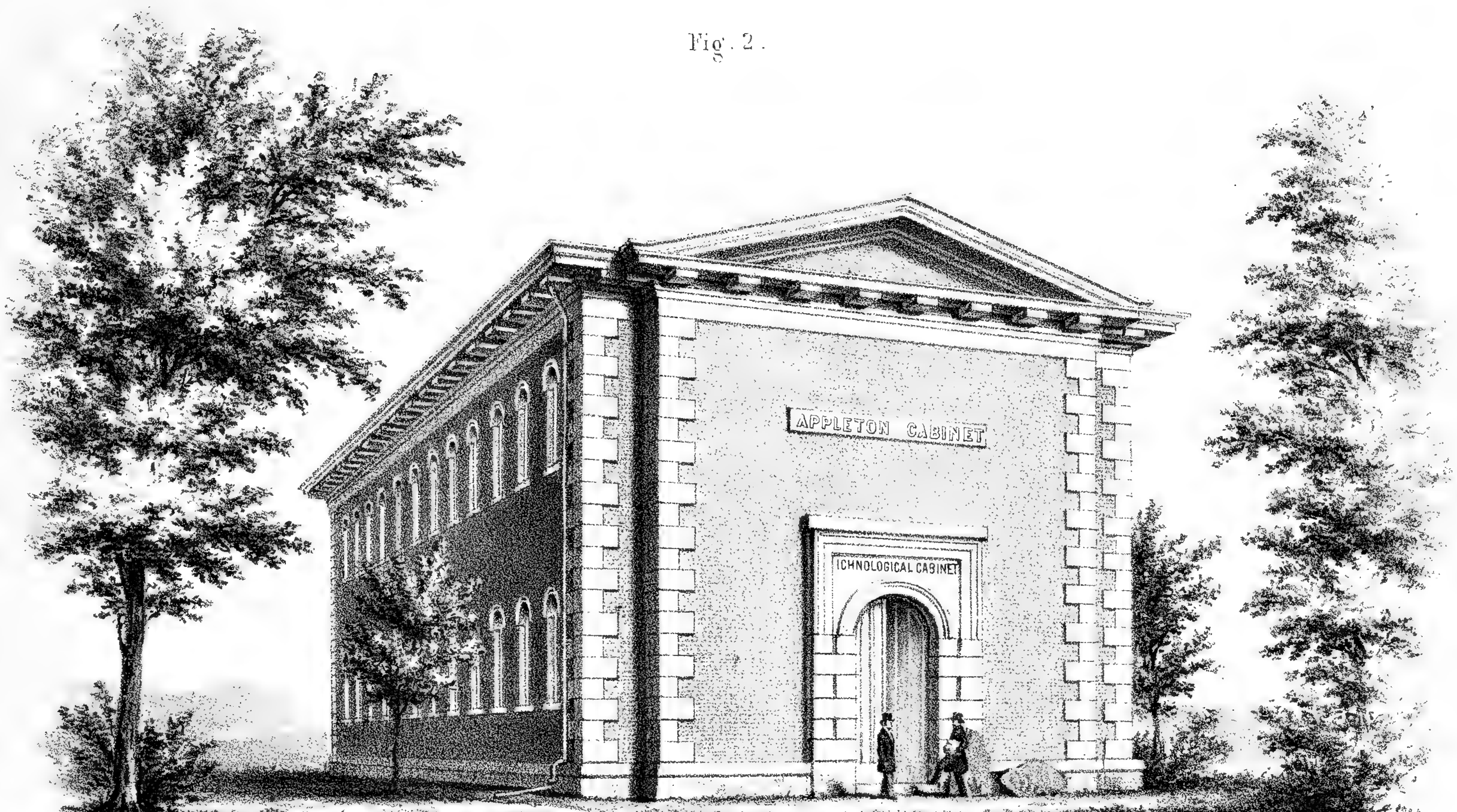

TURNER'S FALLS SECTION
Green River.
Ct River Railroad.
Rocky Mt
Fall River.
Fossil Fish.
Turner's Falls.
Clathropteris.
Coniferae & Insects.
Gill.
Horizontal Scale 200 rods to the inch
Vertical Scale 500 feet to the inch
Connecticut River.
Erving.
TABLETS FOR ALL THE SECTIONS.
Sandstone
Trap
Volcanic Grit
Hypozoic Rocks
Granite
Footmarks
METTAWAMPE SECTION
Deerfield. West Line.
Mill Brook.
South Deerfield.
South Sugar Loaf.
Connecticut River.
Sunderland.
Trap.
Fossil Fish.
Mettawampe.
Leverett W. Line.
Old River Bed.
Horizontal Scale 200 rods to the inch
Vertical Scale 500 feet to the inch
NORWOTTUCK SECTION
Horizontal Scale 200 rods to the inch
Vertical Scale 500 feet to the inch
Lead & Baryta.
Hatfield.
Connecticut River.
Mt Warner
Amherst.
Norwottuck Range.
Mt Tom
S. Hampton Lead Mine.
Horizontal Scale 200 rods to the inch
Vertical Scale 500 feet to the inch
E. Hampton.
Clathropteris.
Connecticut River.
South Hadley.
MOUNT TOM SECTION
Granby.
Rock Rimmon.
Granite.
WEST.
Granite.
EAST.

Fig. 1.

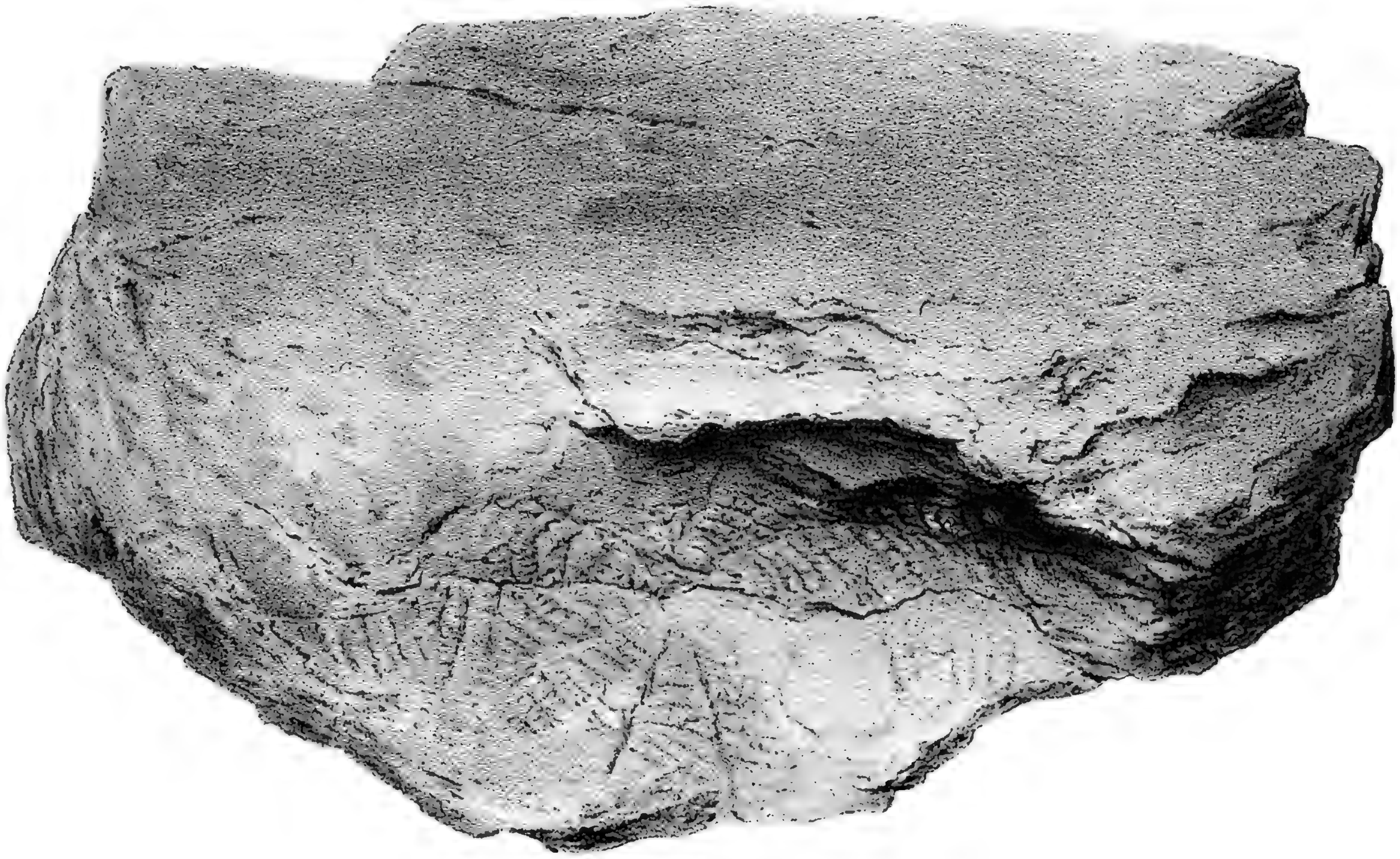
THE ICHNOLOGICAL CABINET

Fig. 2.



THE APPLETON CABINET.

Fig. 1.

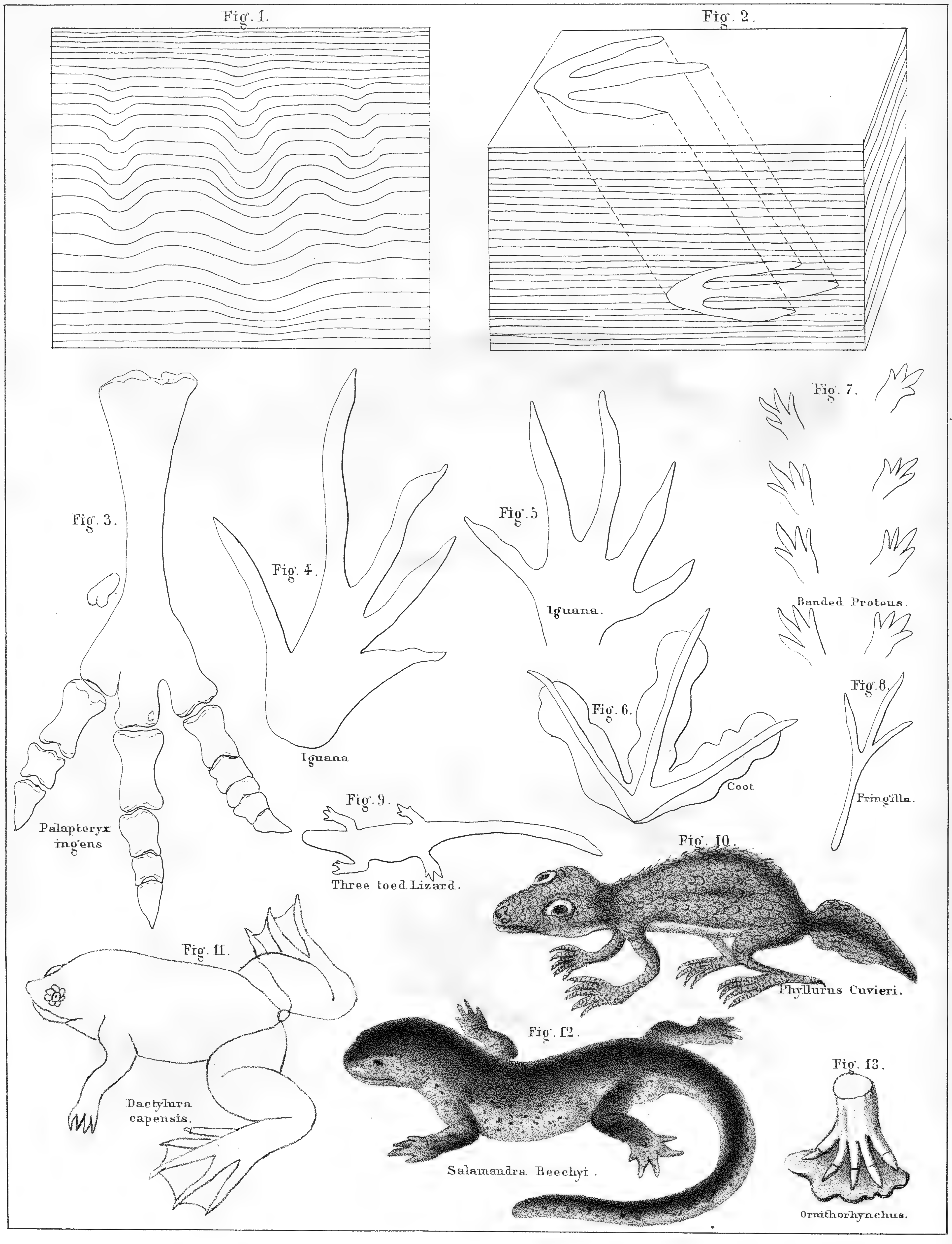


Clathropteris rectiusculus.

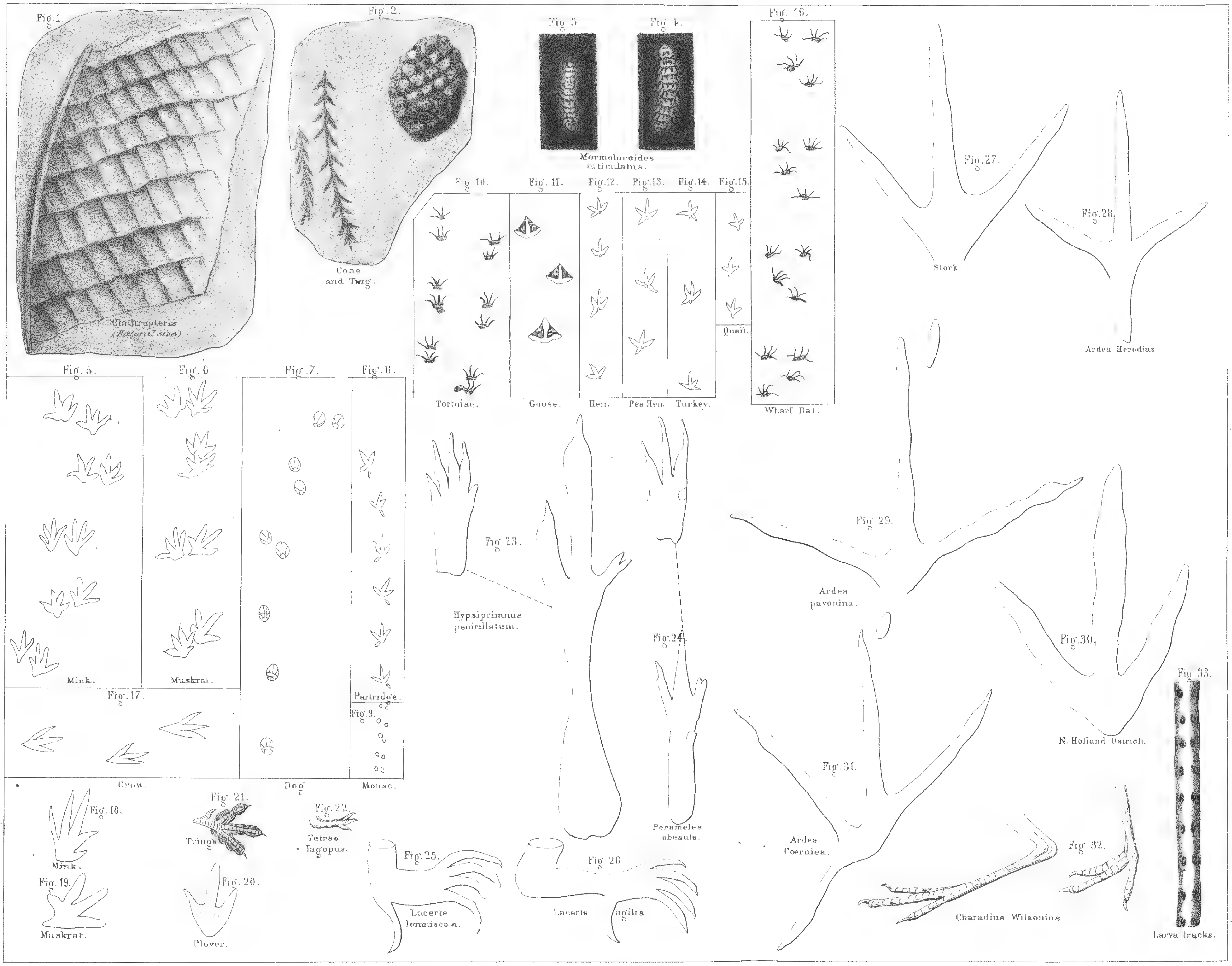
Fig. 2.

Shell in Sandstone.

L. H. Bradford & Co's Lith.



L. H. Bradford & Co's Lith.



L. H. Bradford & Co.s Lith.

Anomœpus major.

L. H. Bradford & Co's lith.

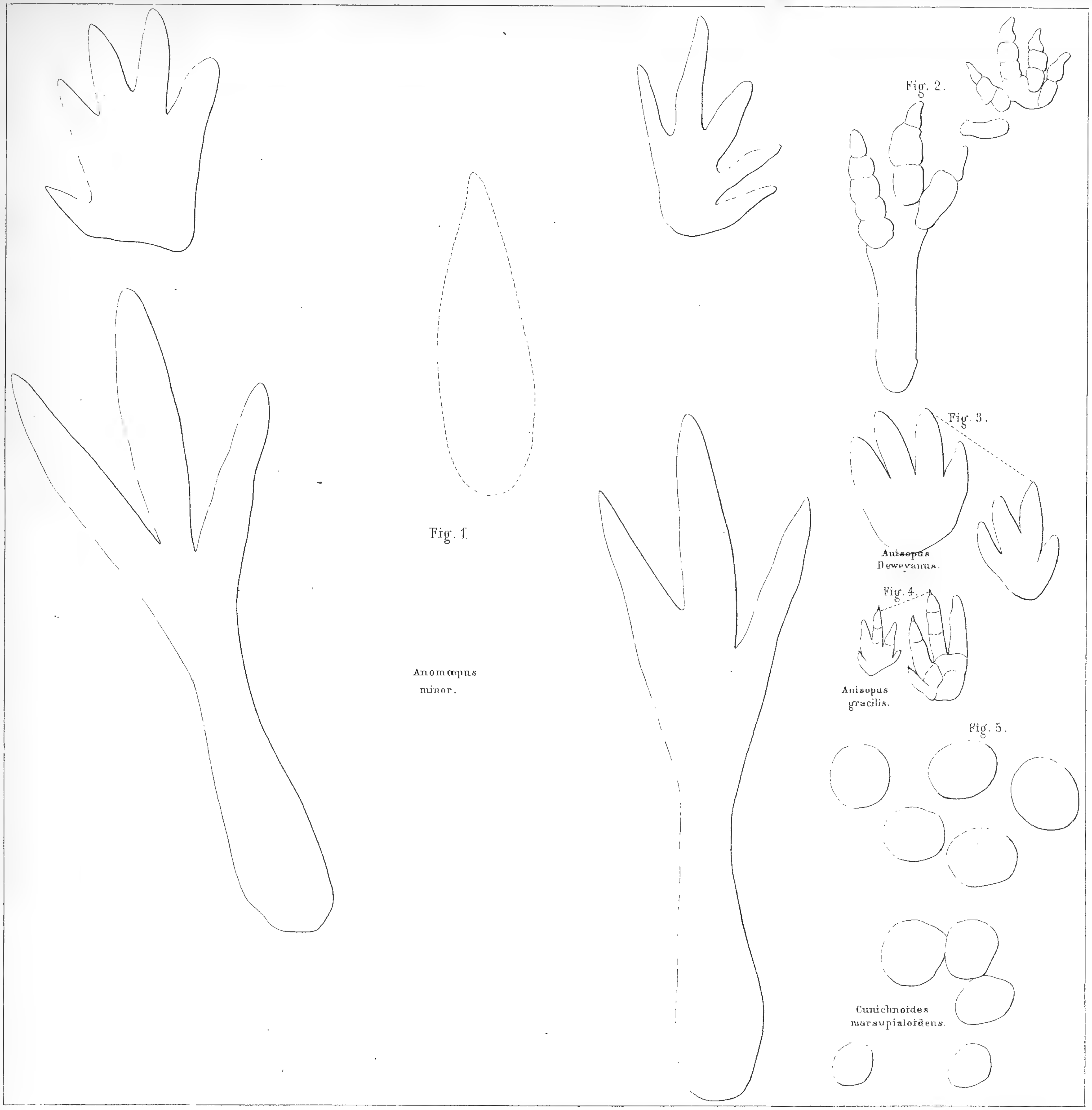


Fig. 1.
Anomœpus
minor.
Fig. 2.
Fig. 3.
Anisopus
Deweyanus.
Fig. 4.
Anisopus
gracilis.
Fig. 5.
Cunichnoides
marsupialoideus.

Brontozoum giganteum.

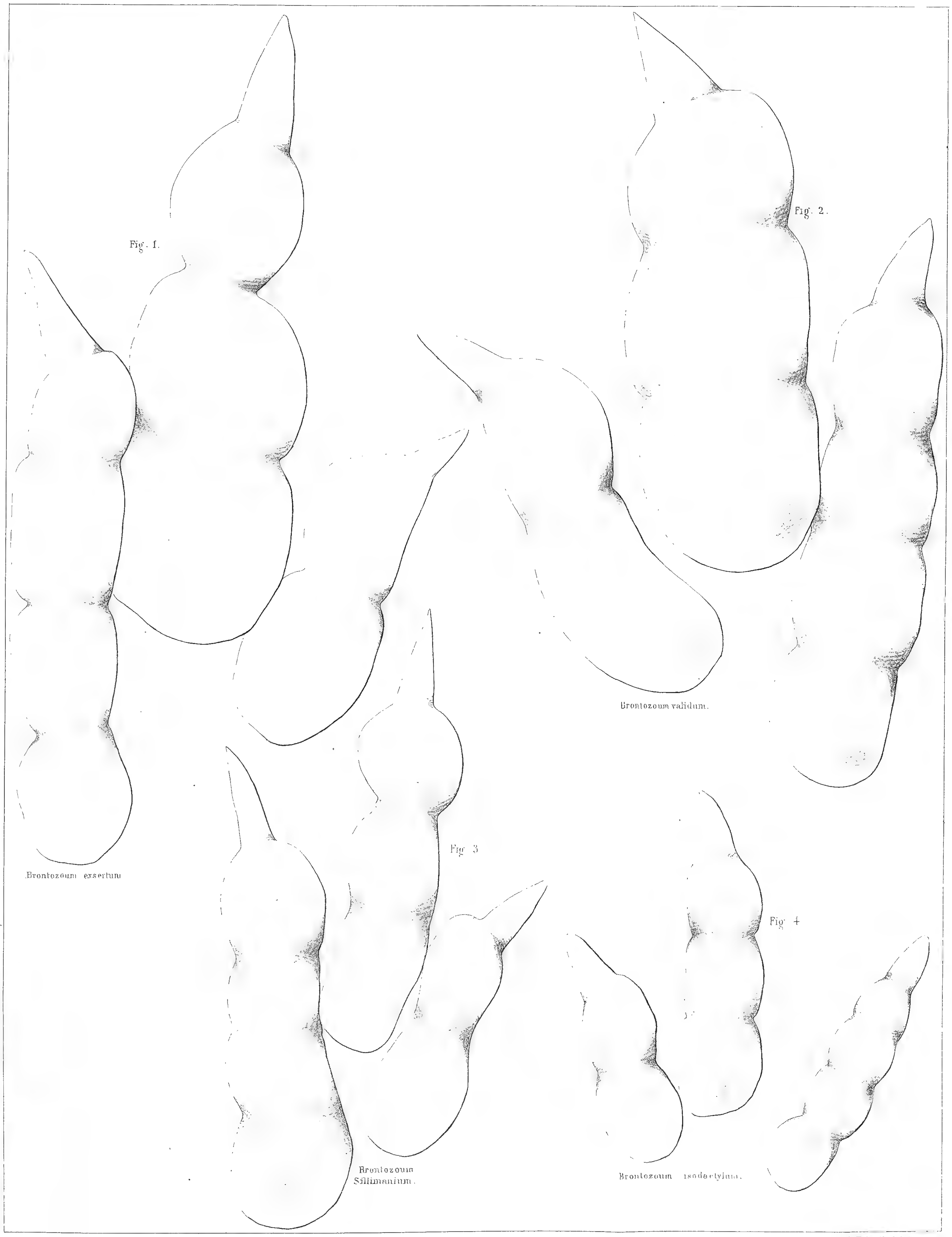
J. H. Bradford & Co's lith.

Fig. 1.

Brontozoum minusculum.

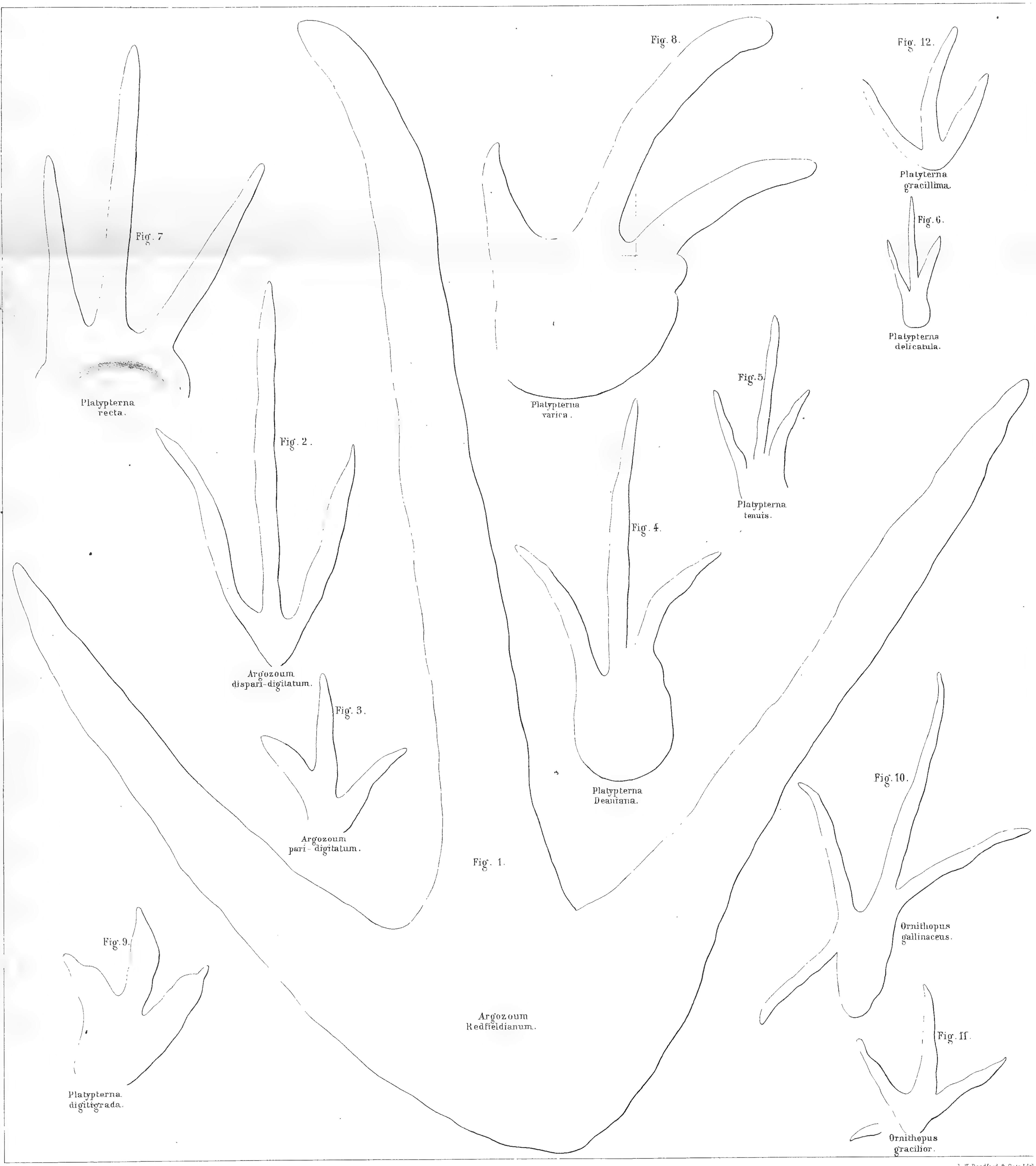
Fig. 2.

Brontozoum tuberatum.

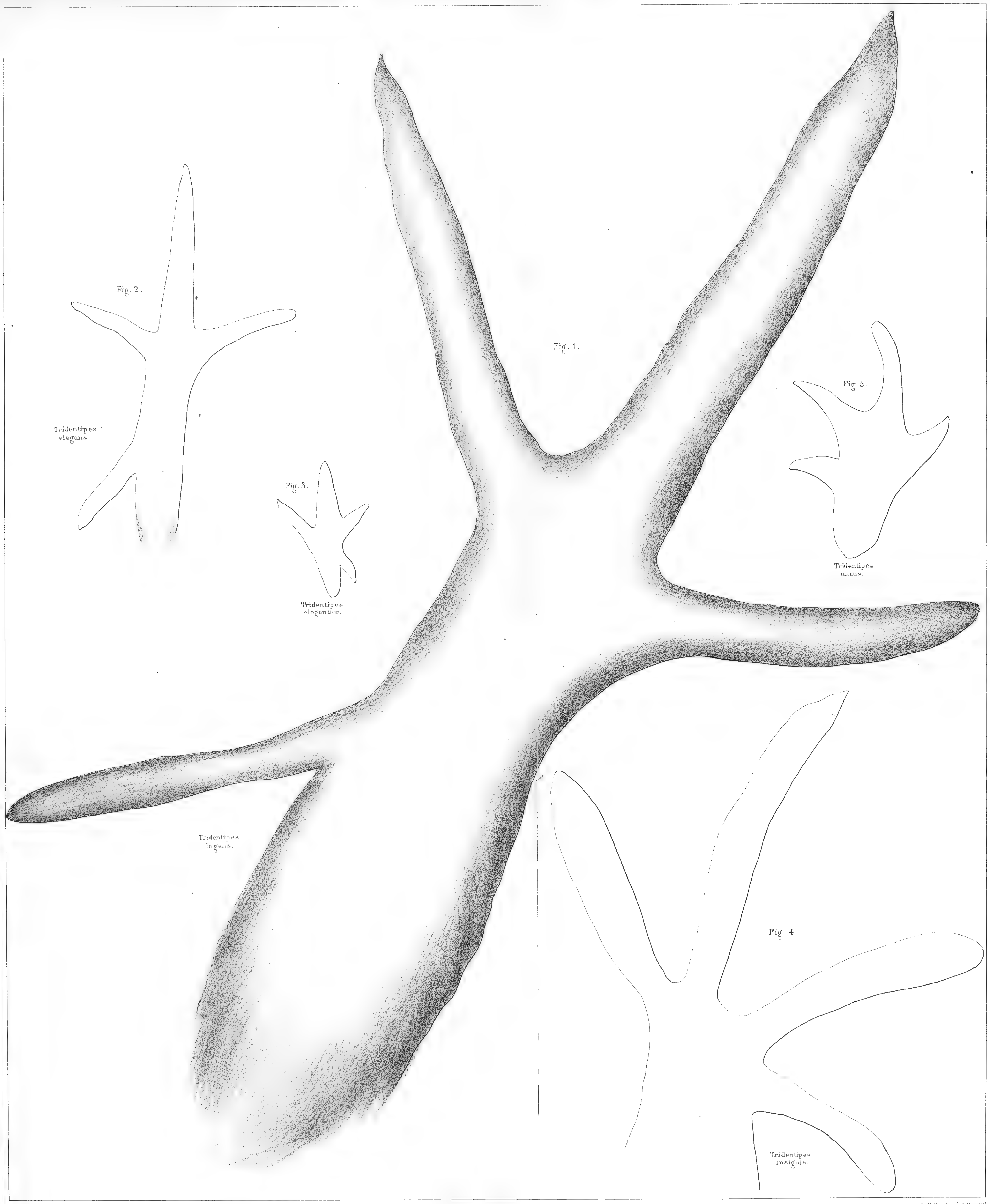


H. Bradford & Co

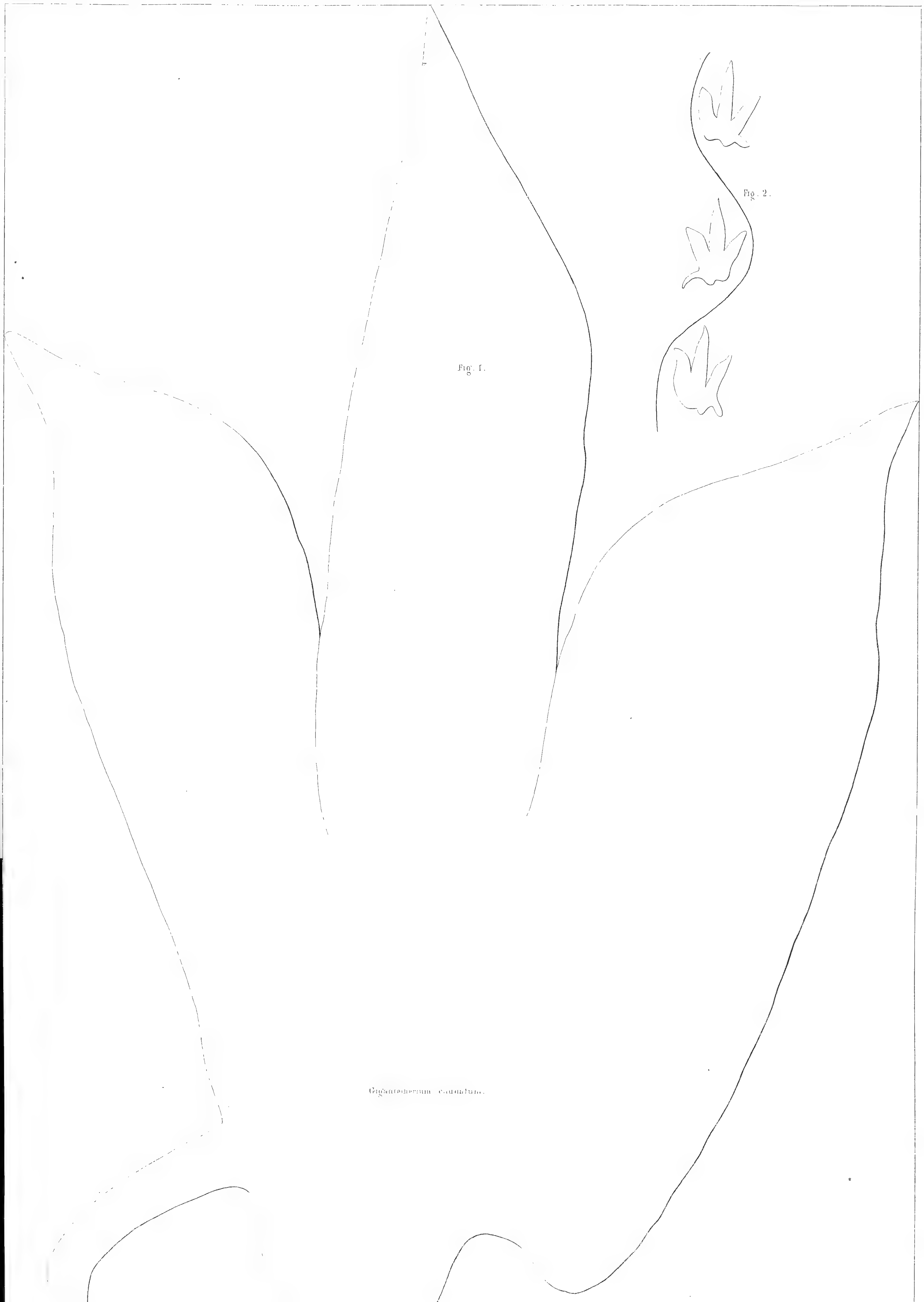

Fig. 1.
Amblyonix Giganteus.
Fig. 4.
Grallator tennis.
Fig. 6.
Grallator cuneatus.
Fig. 5.
Grallator gracillimus.
Fig. 2.
Amblyonix Lyellianus.
Fig. 3.
Grallator cursorius.



J. H. Bradford & Co's Lith.



L. H. Bradford & Co's lith.



Gigantodermum caudatum.

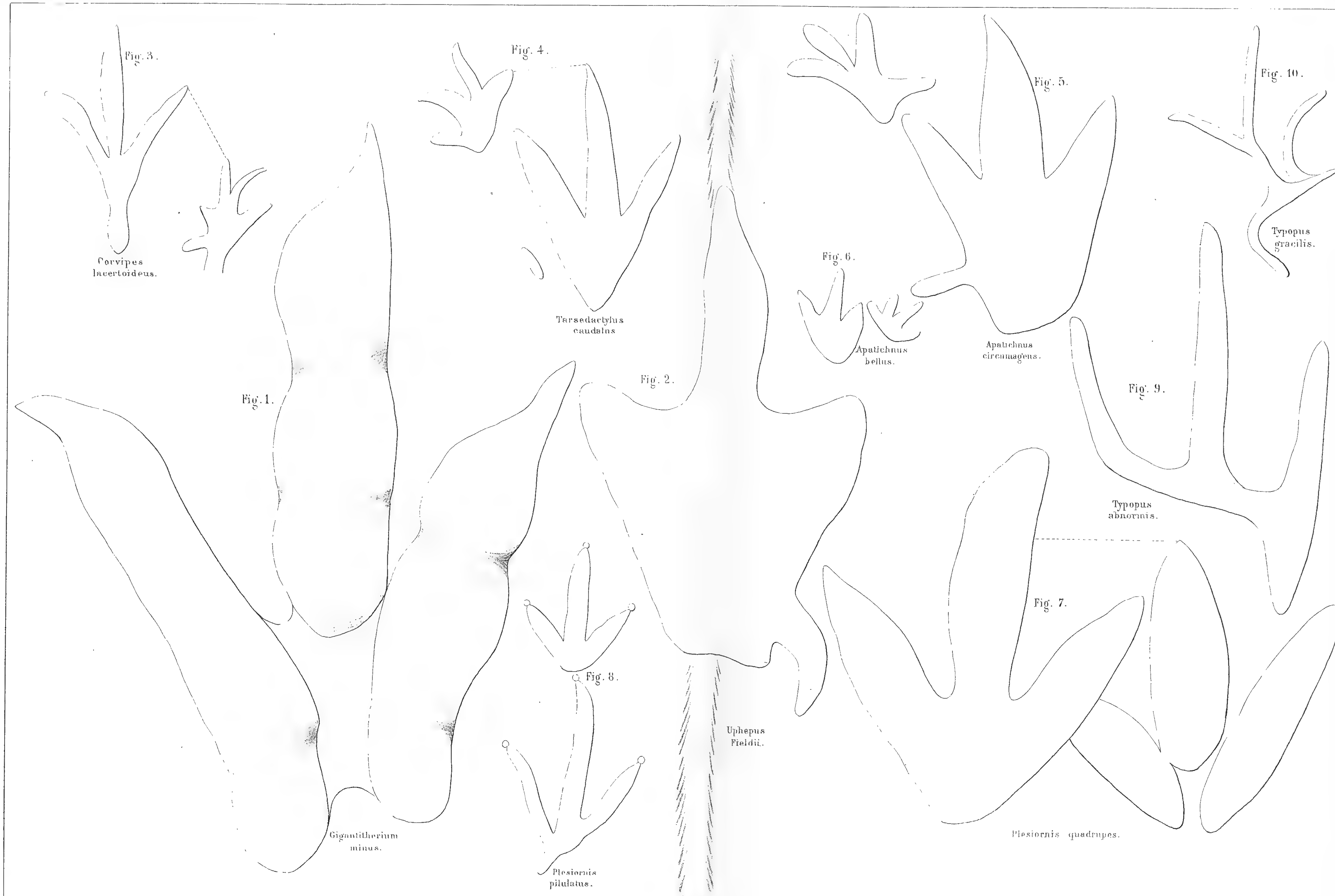
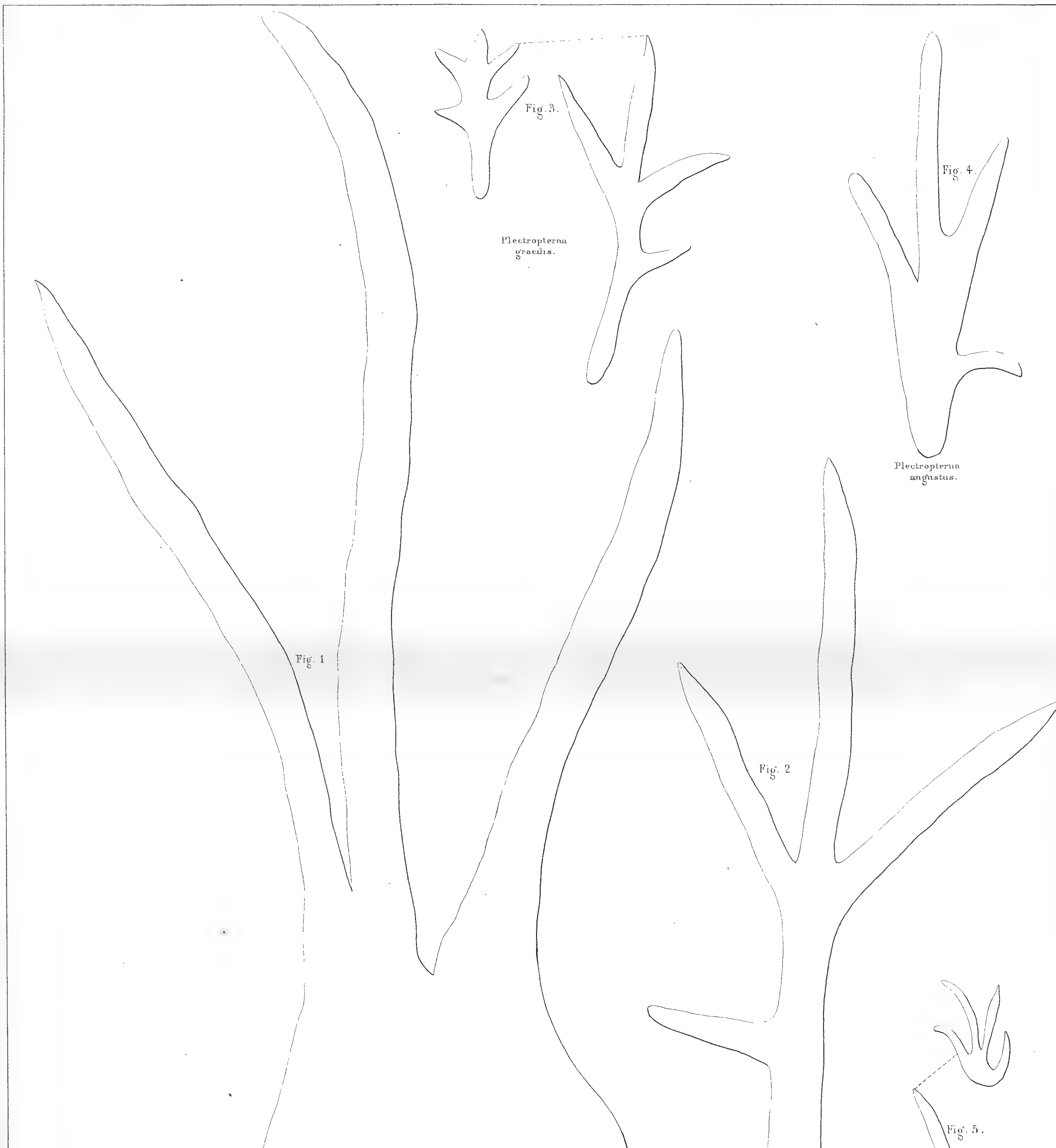
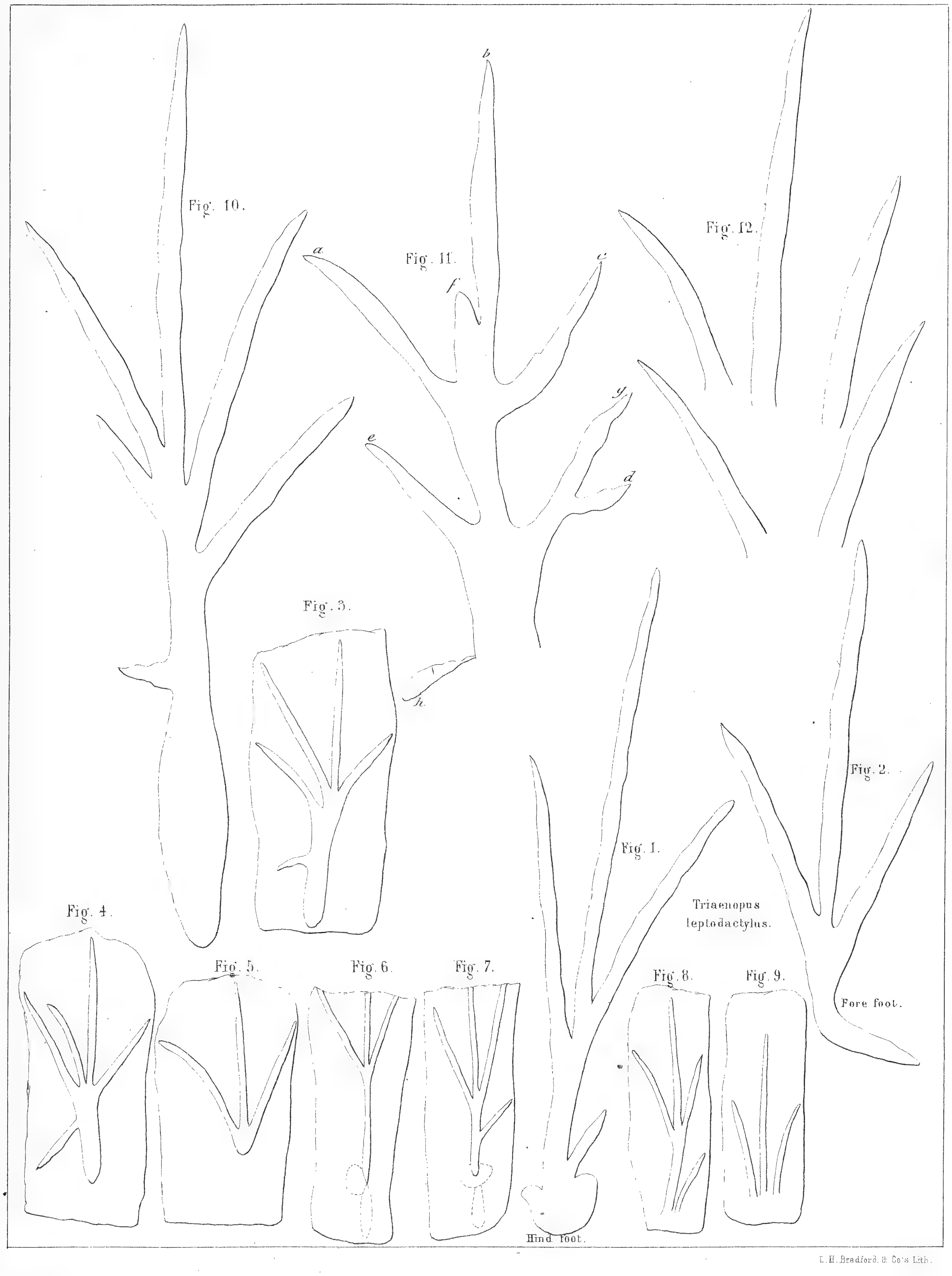


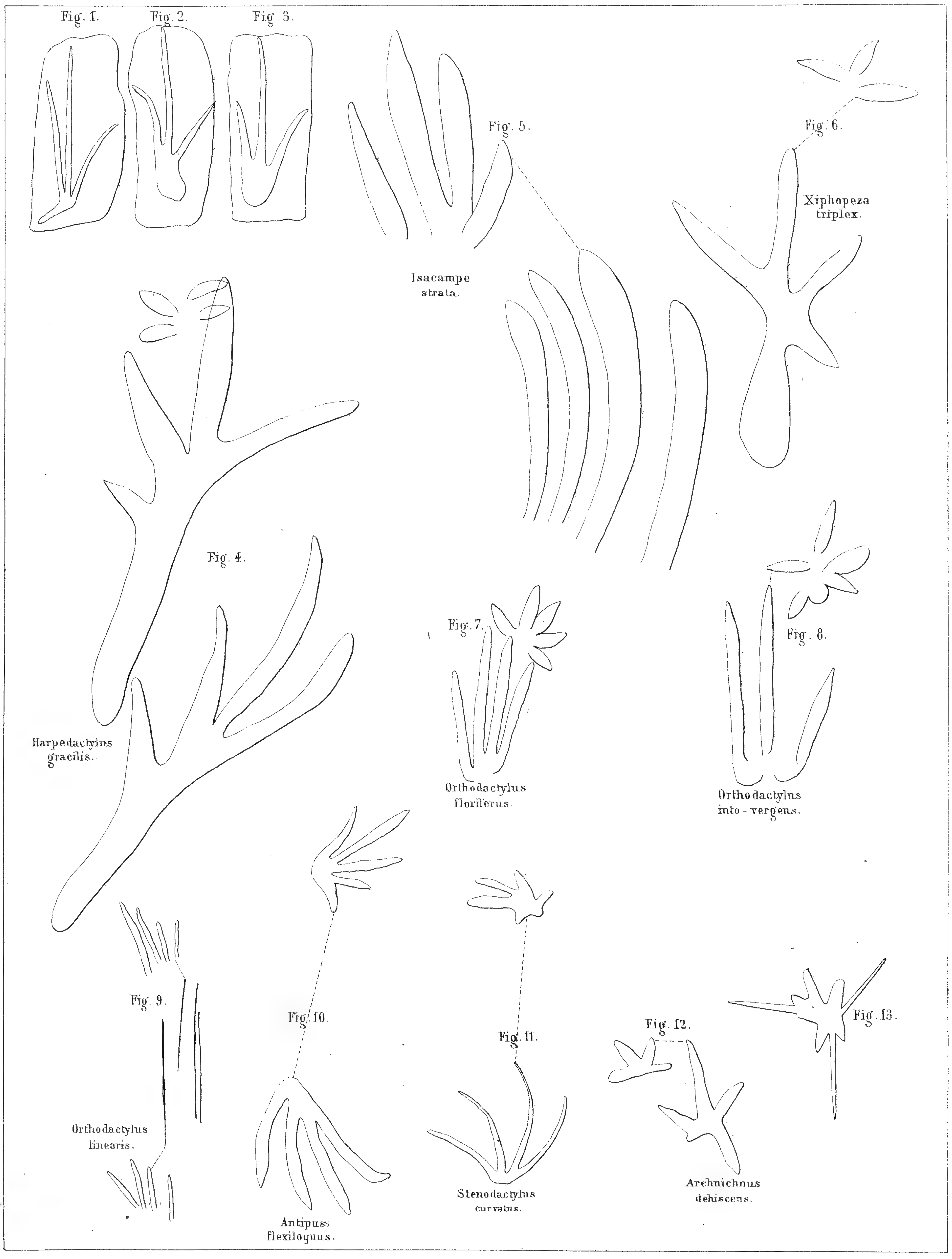
Fig. 3.
Corvipes lacertoideus.
Fig. 4.
Tarsodactylus caudatus
Fig. 5.
Fig. 10.
Typopus gracilis.
Fig. 6.
Apatichnus bellus.
Apatichnus circumagens.
Fig. 1.
Fig. 2.
Fig. 9.
Typopus abnormis.
Fig. 7.
Fig. 8.
Gigantitherium minus.
Plesiornis pilulatus.
Uphepus Fieldii.
Plesiornis quadrupes.



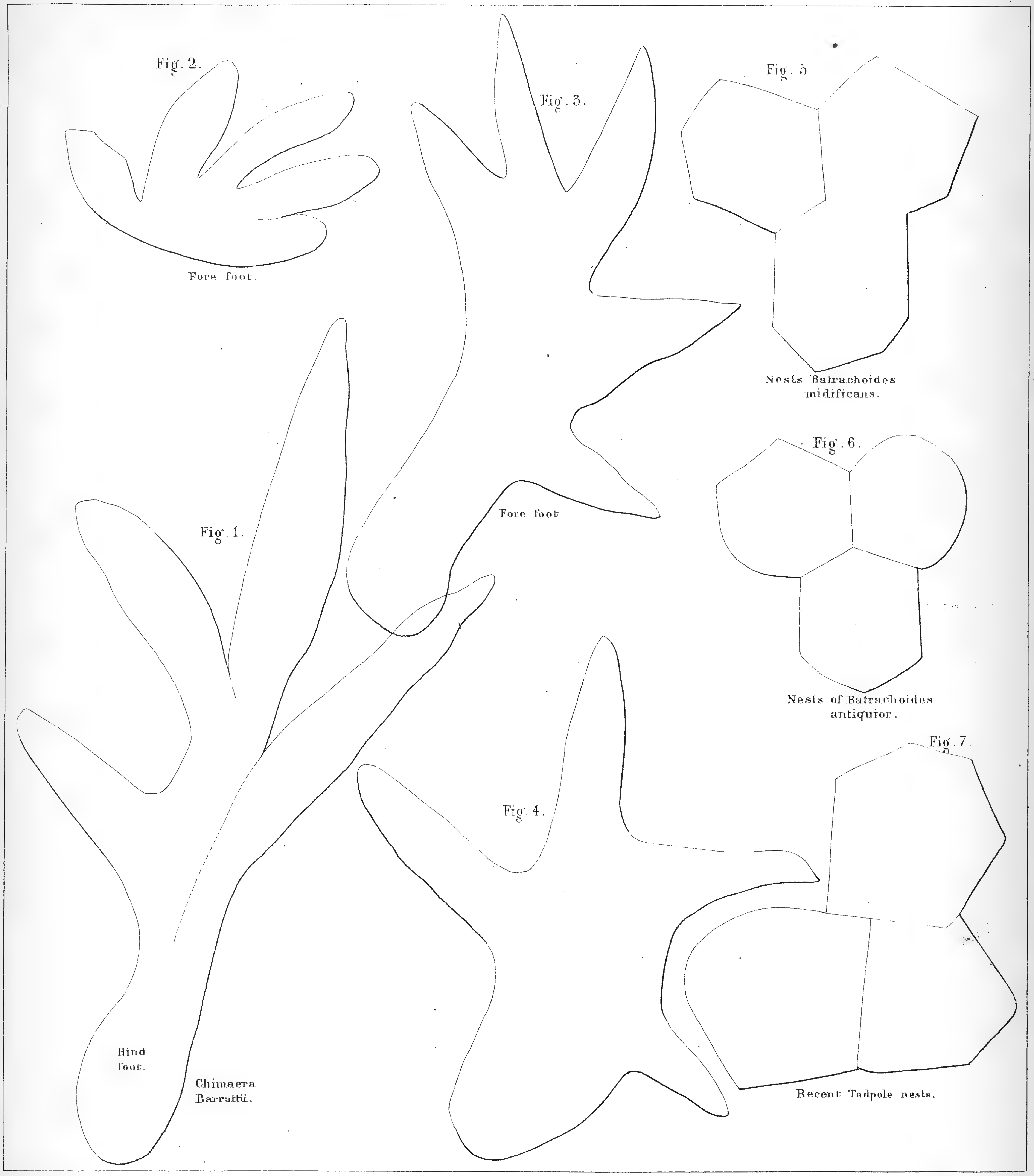
L. H. Bradford & Co's lith.



L. H. Bradford & Co's Lith.



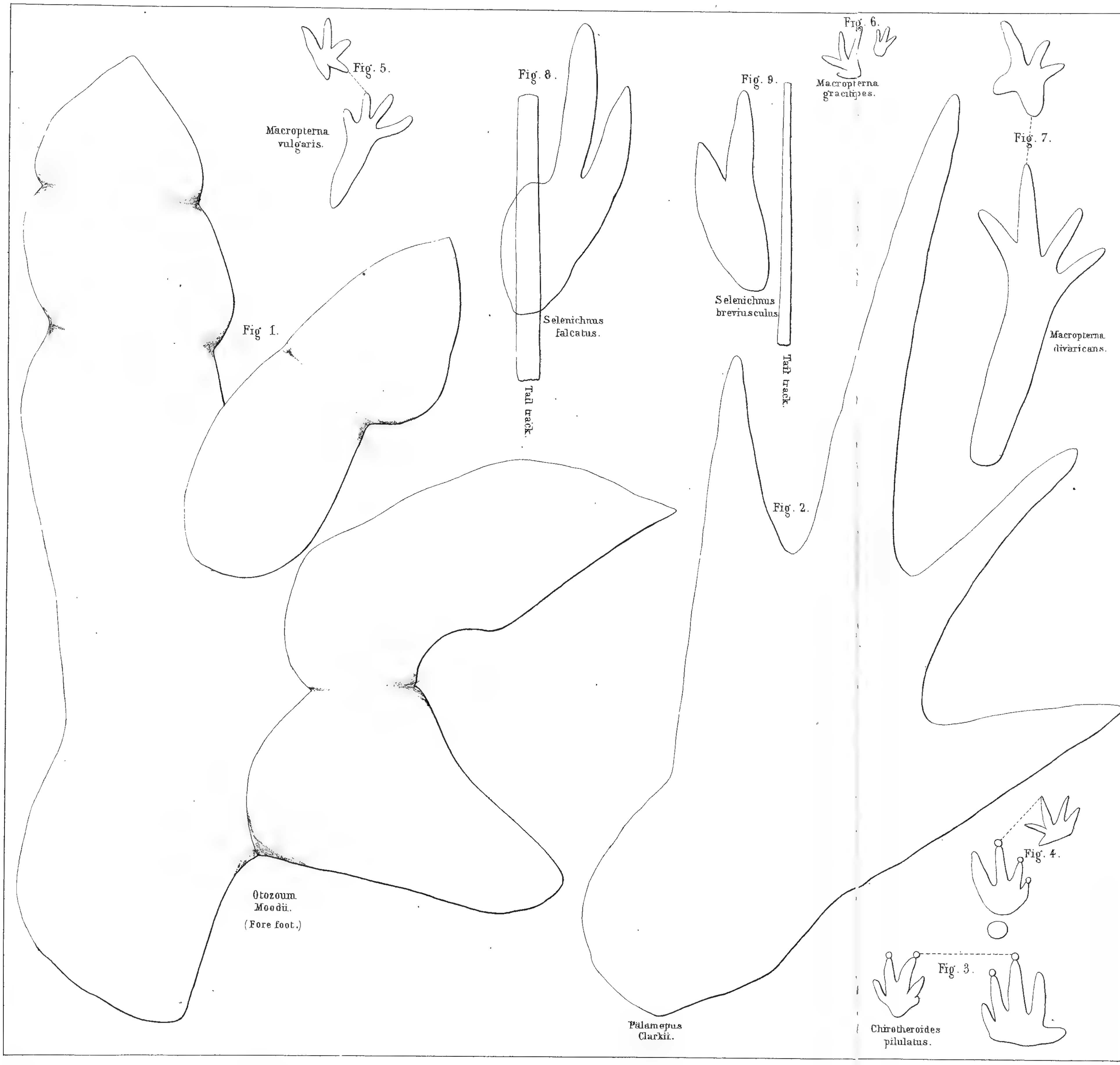
L. H. Bradford & Co's Lith.



L. H. Bradford & Co's Lith.

Otozoum Moodii
(Hind foot.)

Pl XXIII.



L H Bradford & Co's Lith.

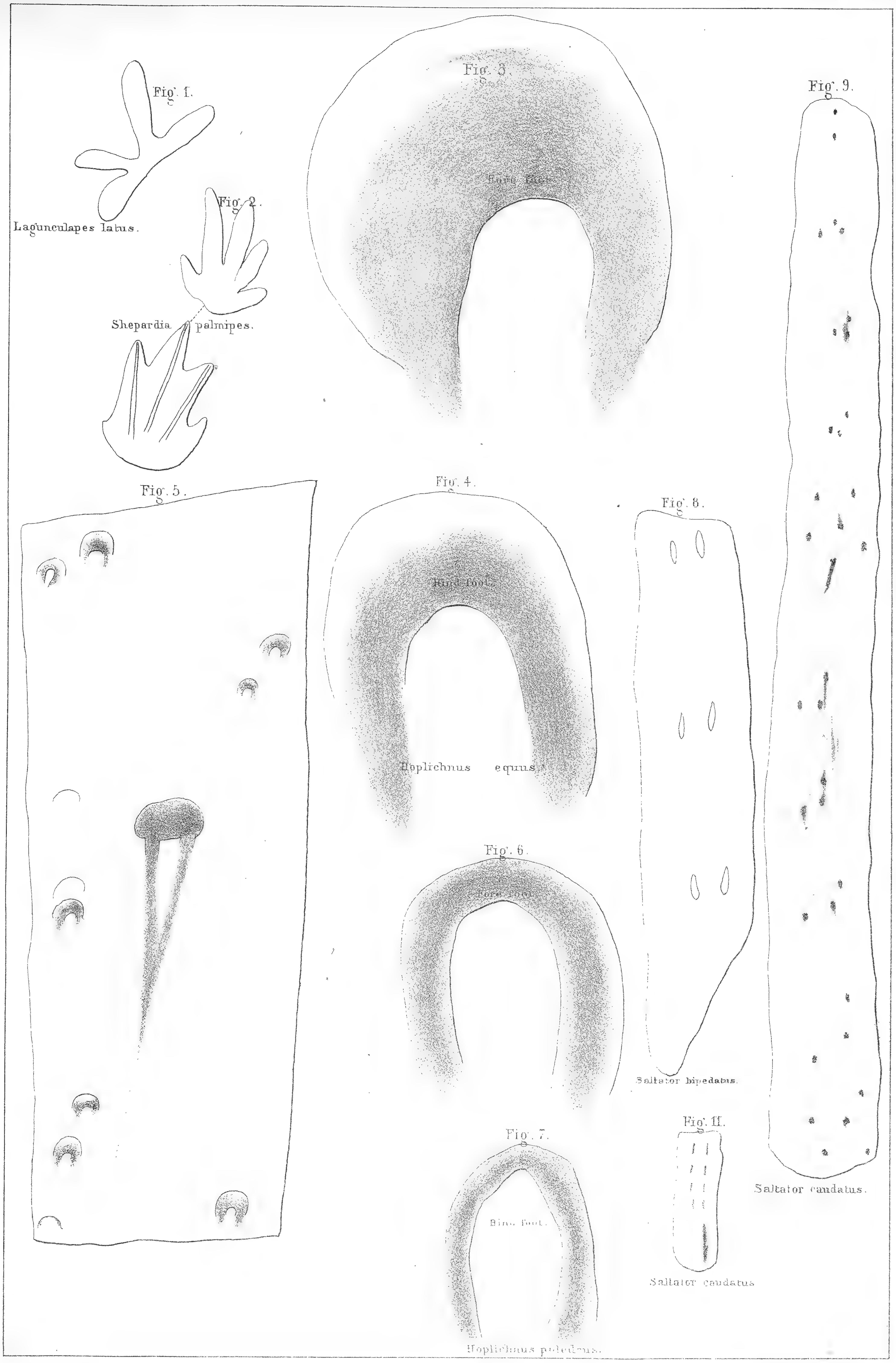
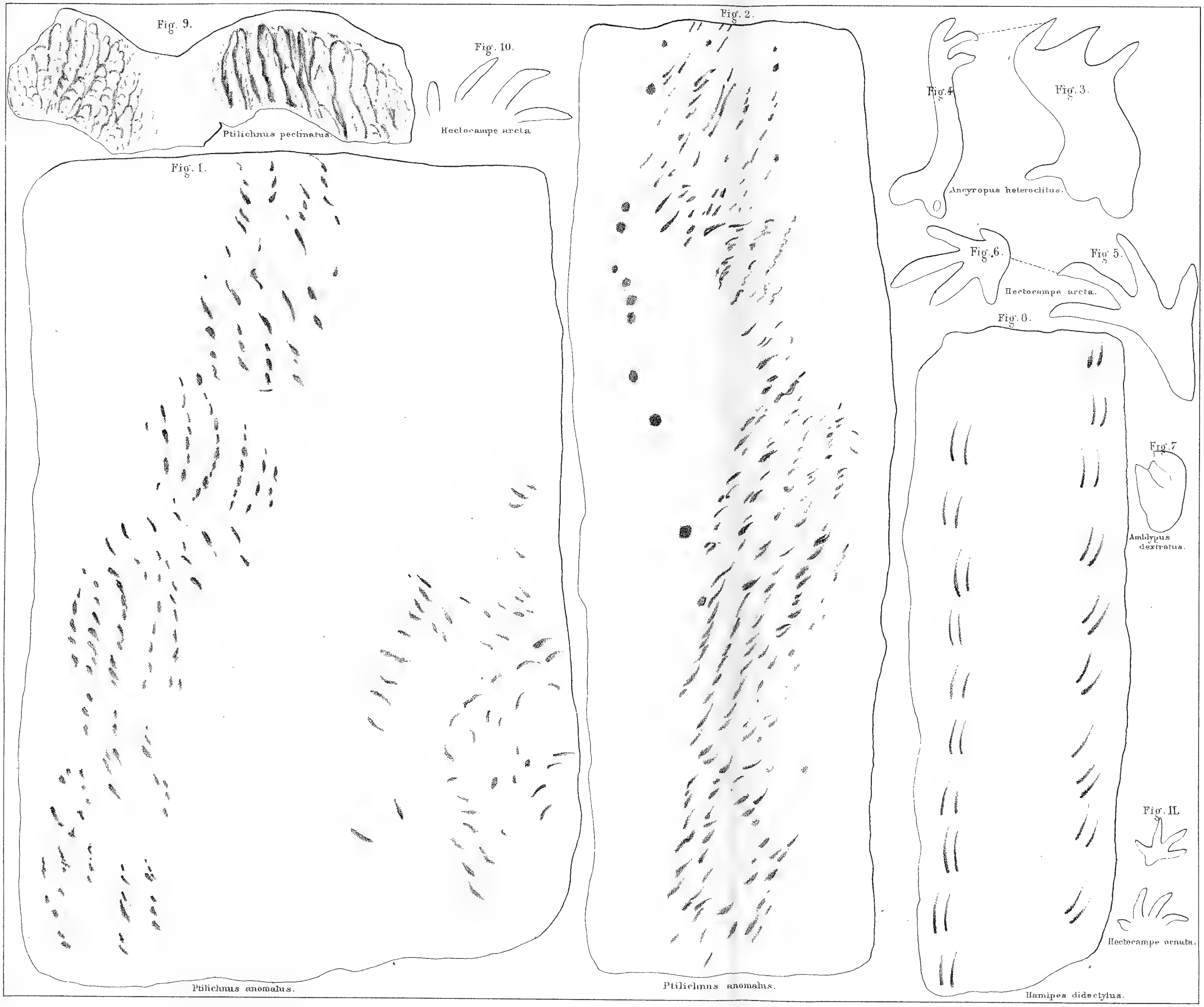
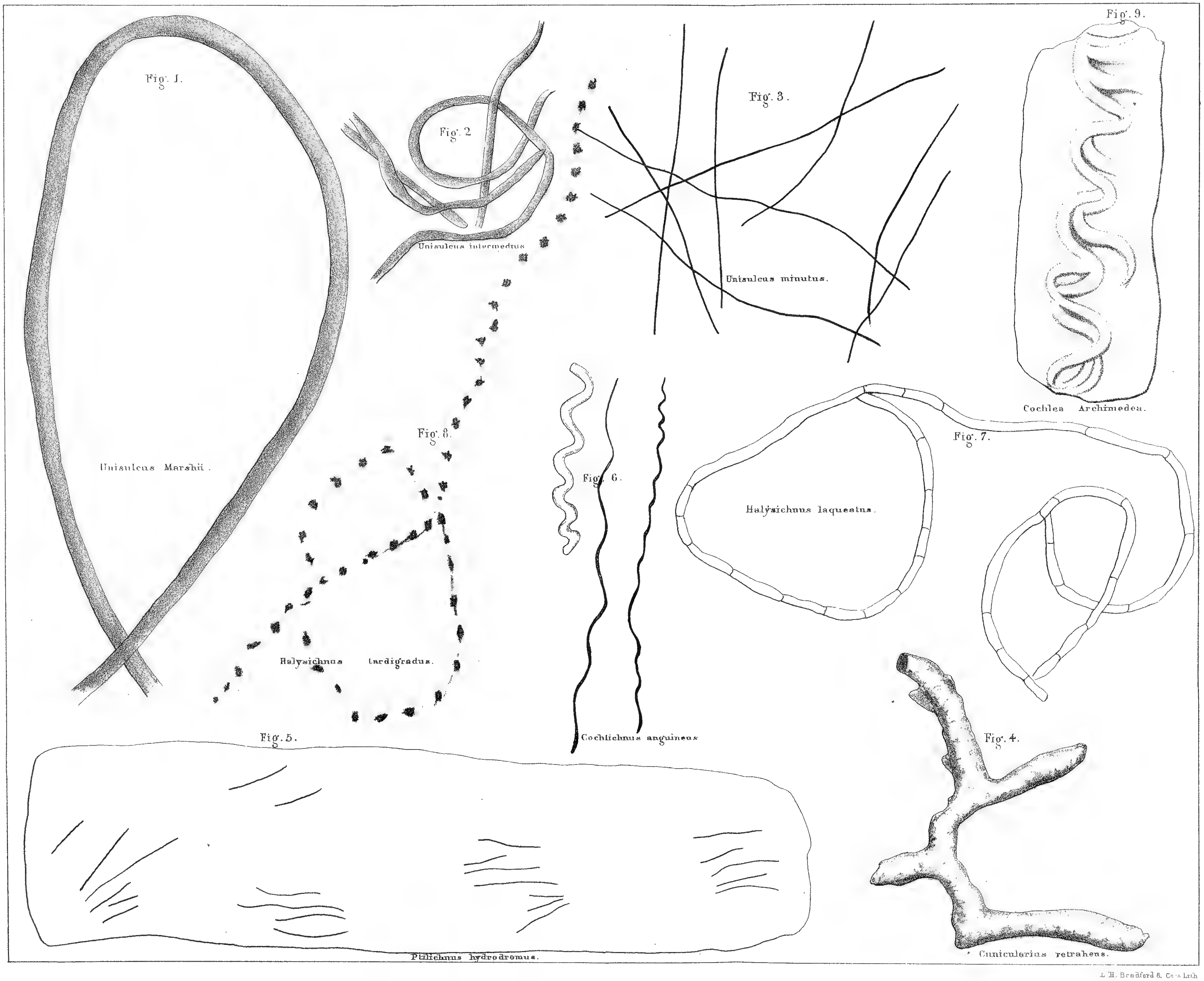


Fig. 1.
Lagunculapes latus.
Fig. 2.
Shepardia palmipes.
Fig. 3.
Fore foot.
Fig. 9.
Fig. 4.
Hind foot.
Hoplichnus equus.
Fig. 5.
Fig. 8.
Fig. 6.
Saltator bipedatus.
Fig. 7.
Hind foot.
Fig. 11.
Saltator caudatus.
Saltator caudatus.
Hoplichnus poledrus.

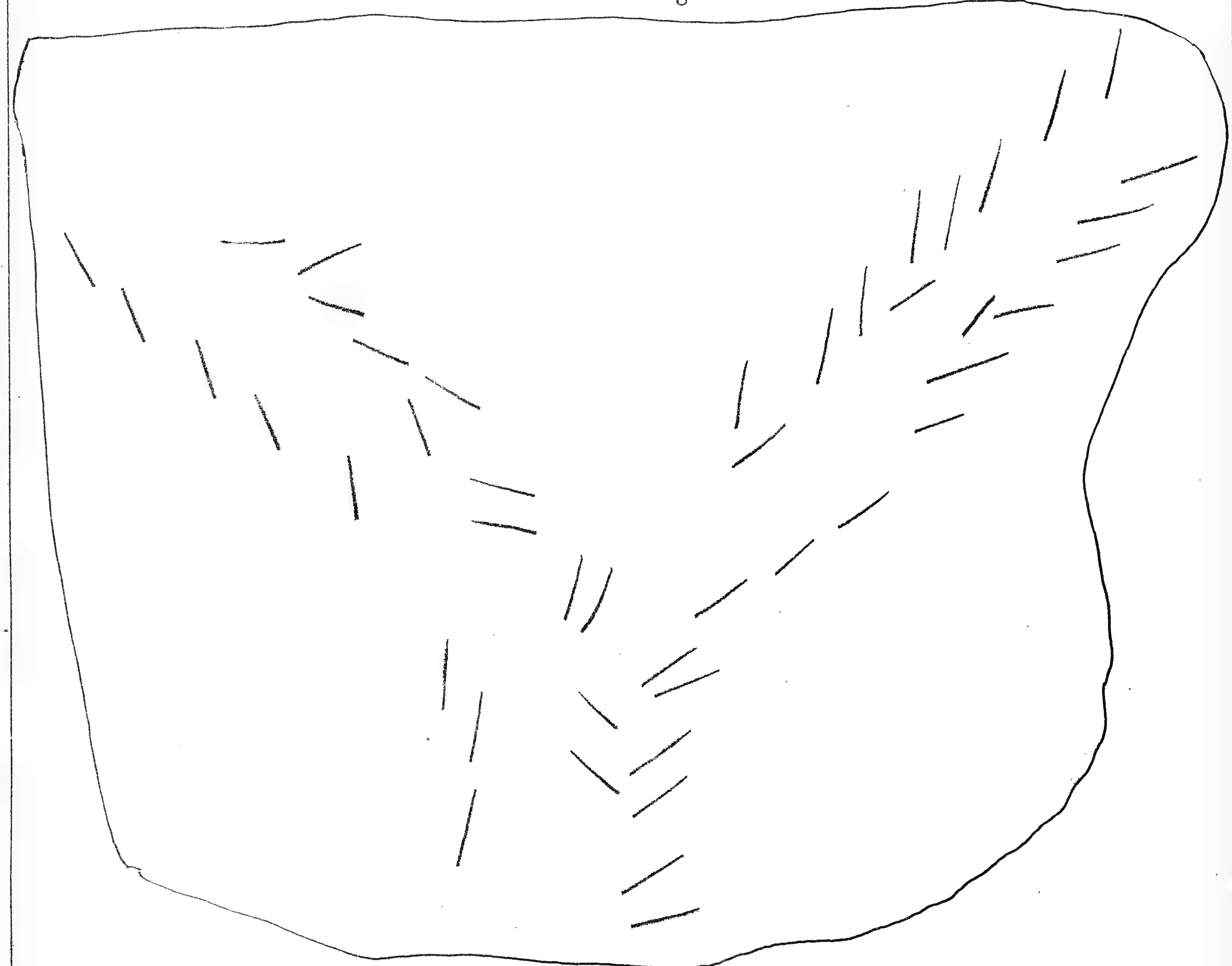


L. H. Bradford & Co's Lith.



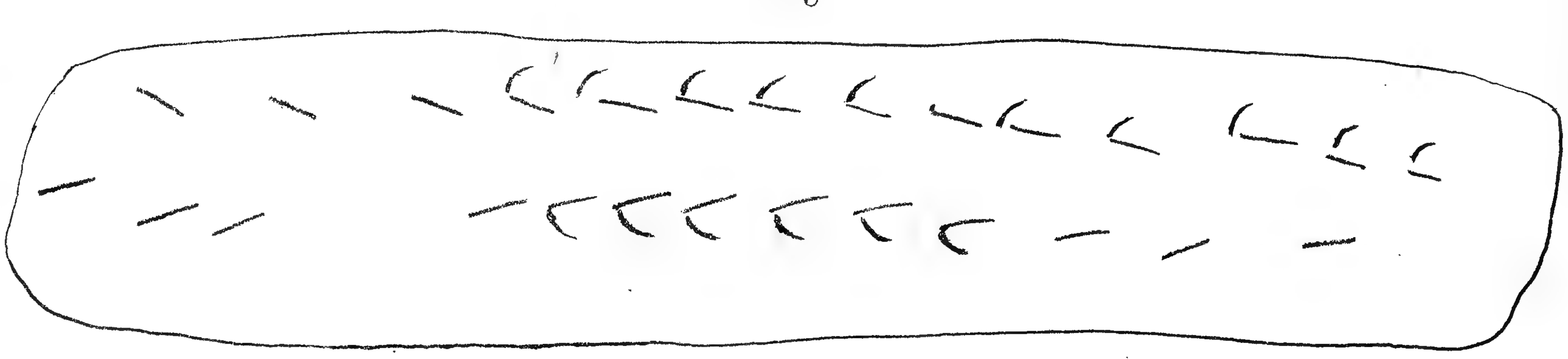
J. H. Bradford & Co's Lith

Fig. 1.



Bifurculapes scolopendroideus.

Fig. 2.



Lithographus hieroglyphicus.

L. H. Bradford & Co's Lith.

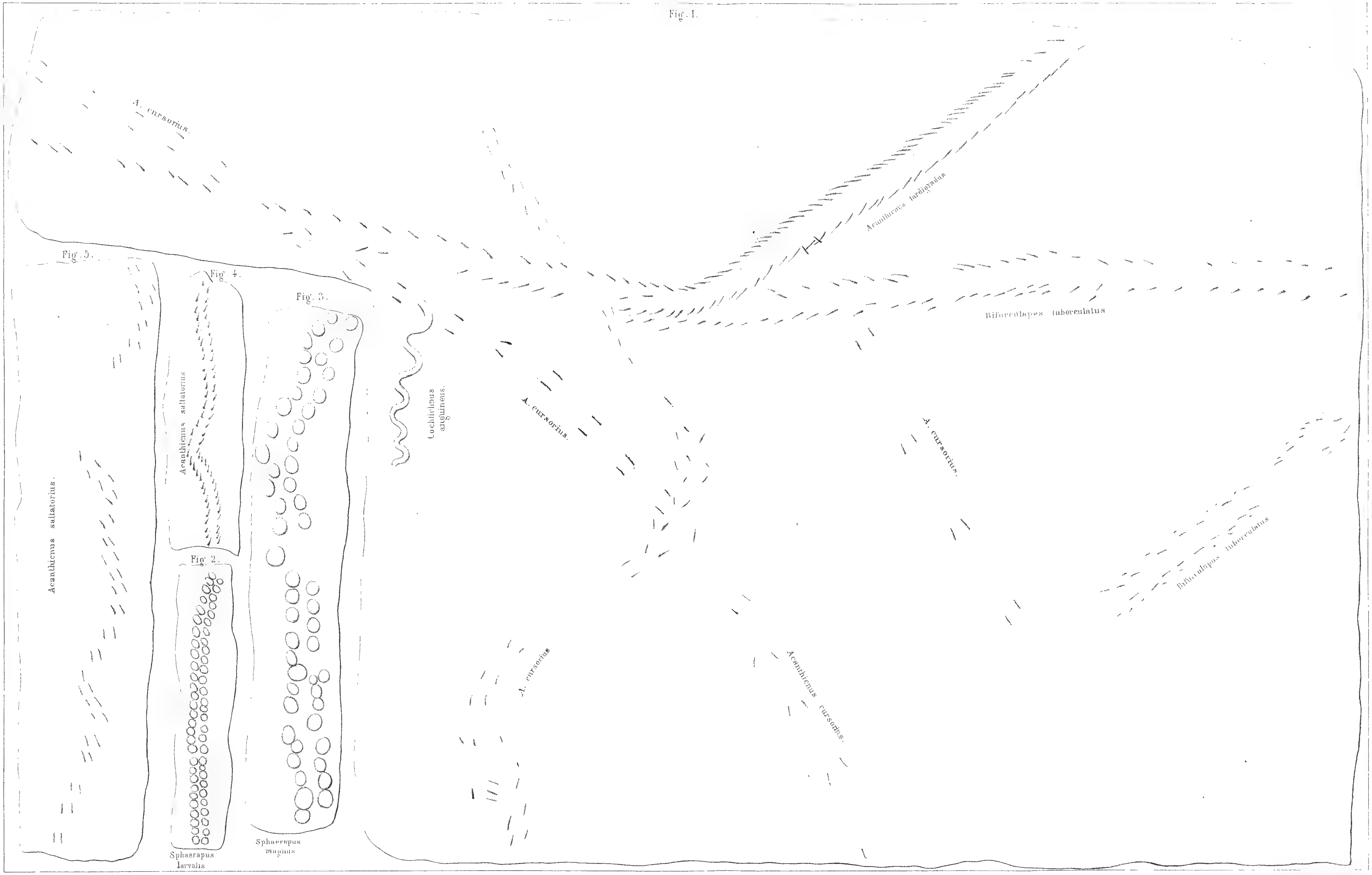
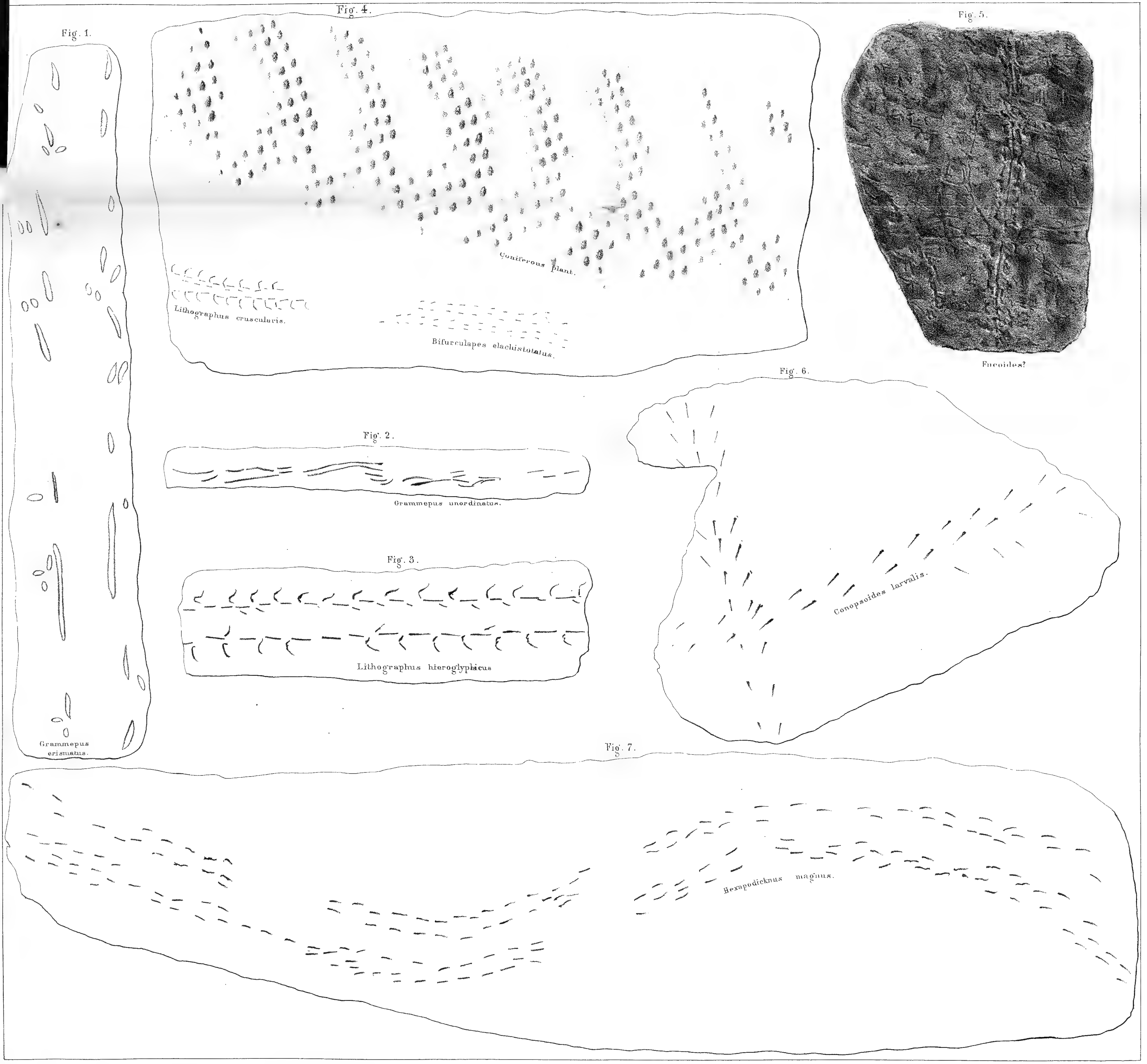
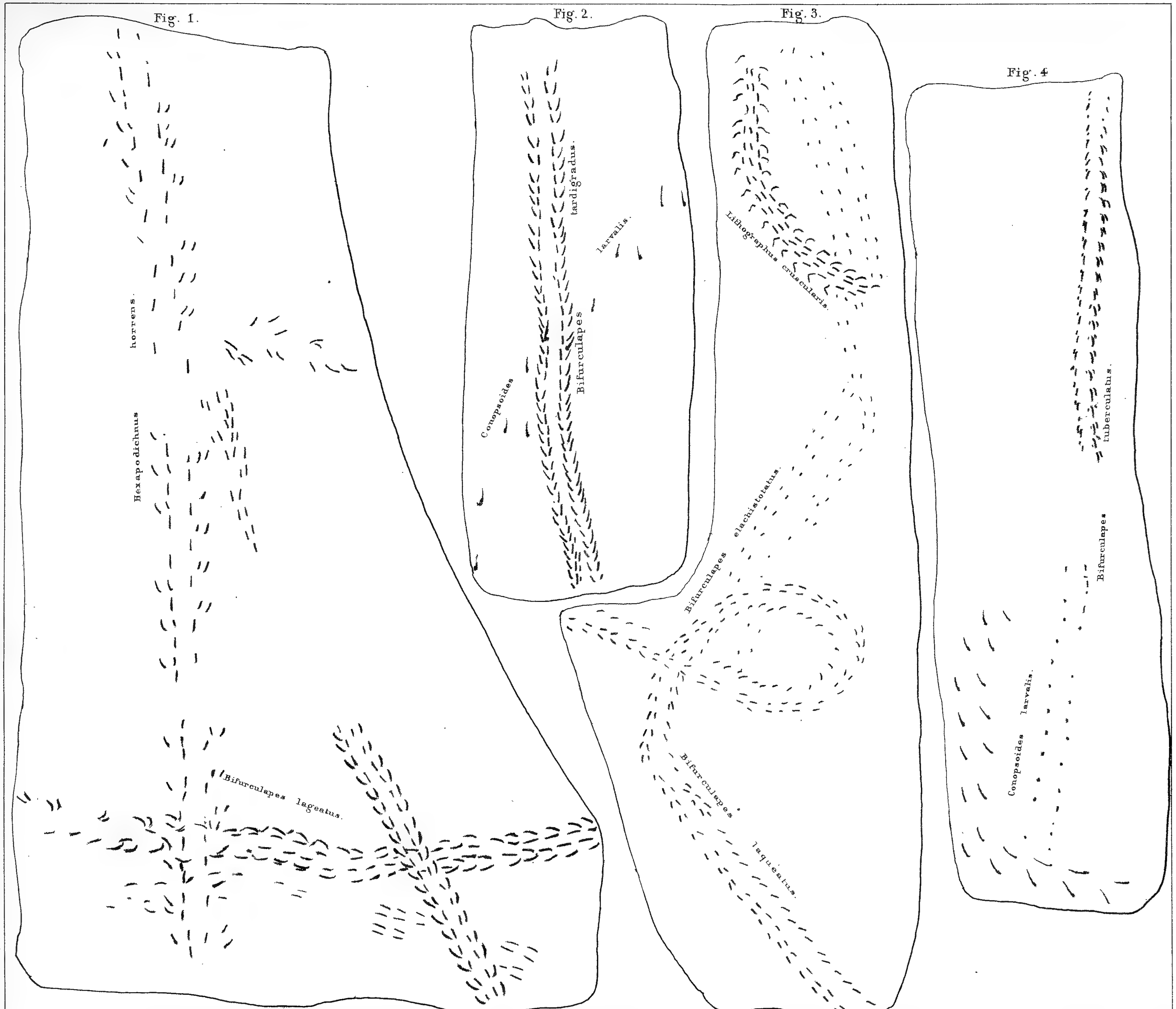


Fig. 1.
A. cursorius.
Acanthicnus tardigradus
Bifurculapes tuberculatus
Cochlichnus anguineus.
A. cursorius.
A. cursorius.
Bifurculapes tuberculatus
A. cursorius
Acanthicnus cursorius.
Fig. 5.
Acanthicnus saltatorius.
Fig. 4.
Acanthicnus saltatorius
Fig. 2.
Sphaerapus larvalis
Fig. 3.
Sphaerapus magnus



L. H. Bradford & Co's Lith.



L. H. Bradford & Co's Lith.

Fig. 1.

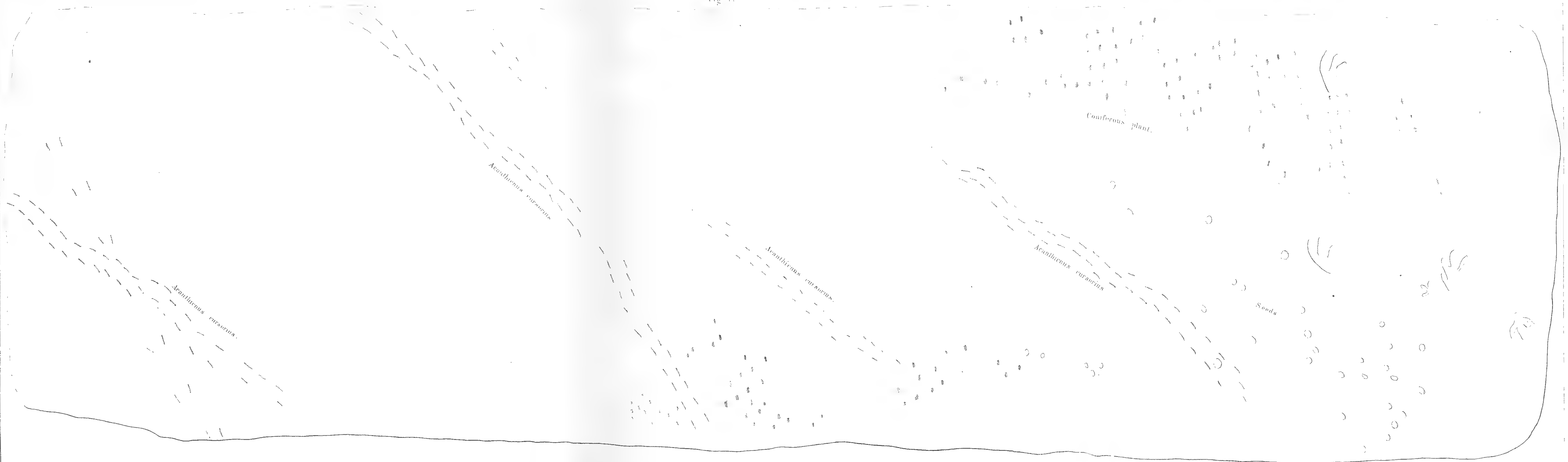
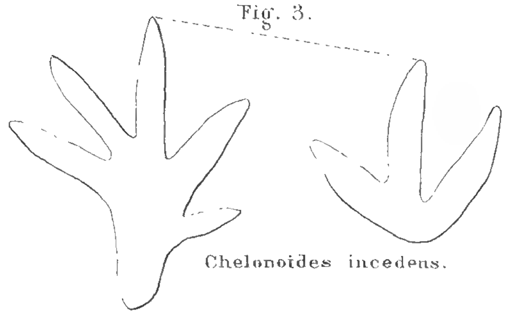


Fig. 2.

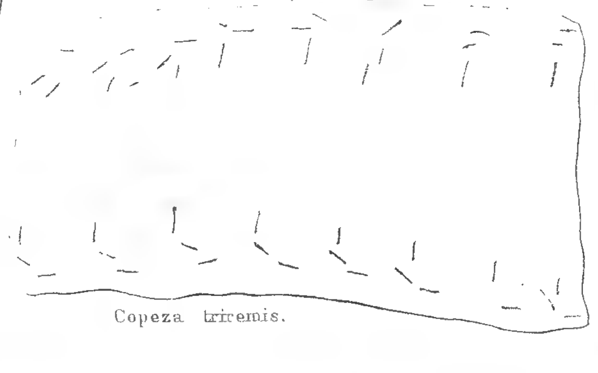
Snipes track and rain drops.

Fig. 3.



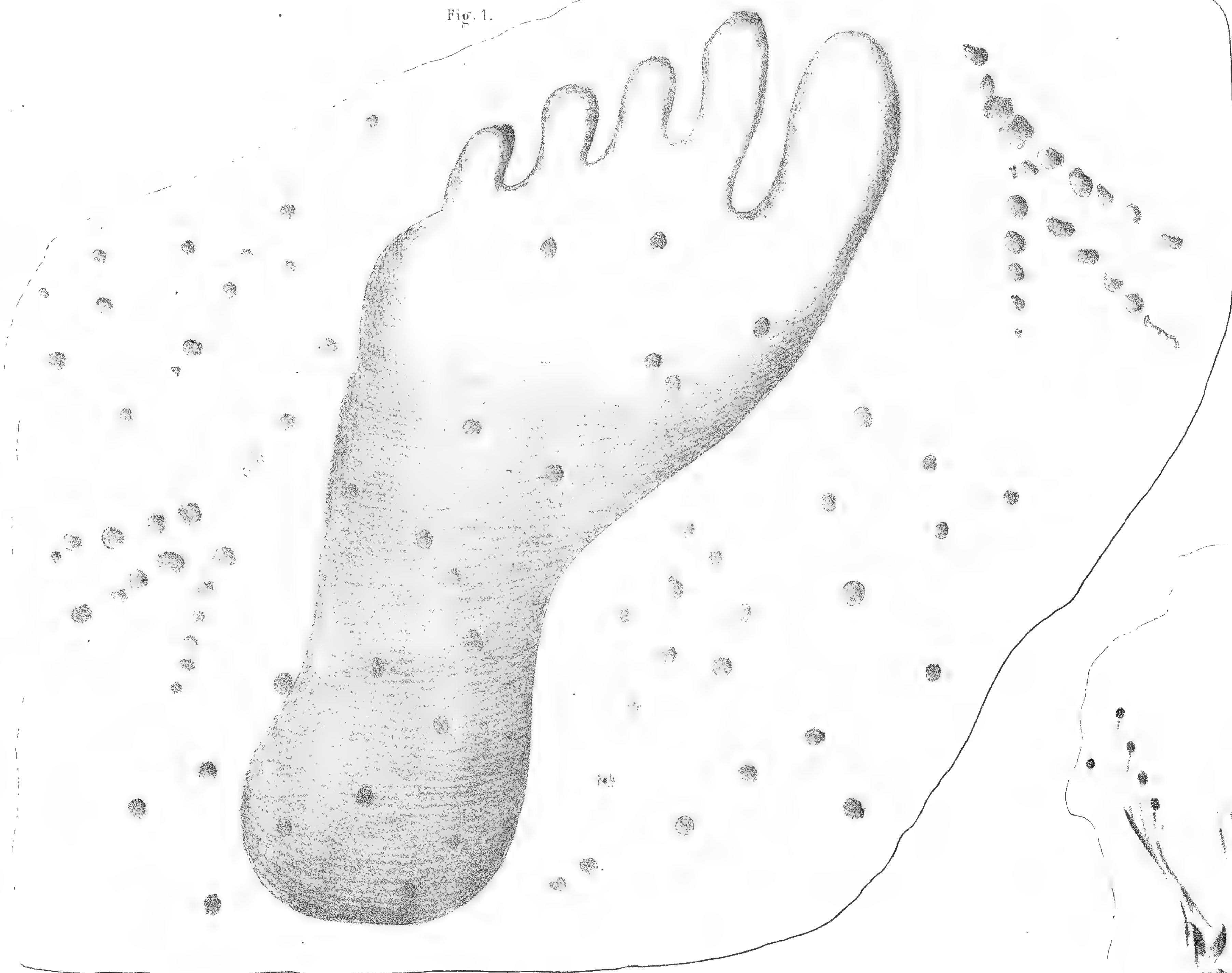
Chelonoides incedens.

Fig. 4.



Copeza triremis.

Fig. 1.

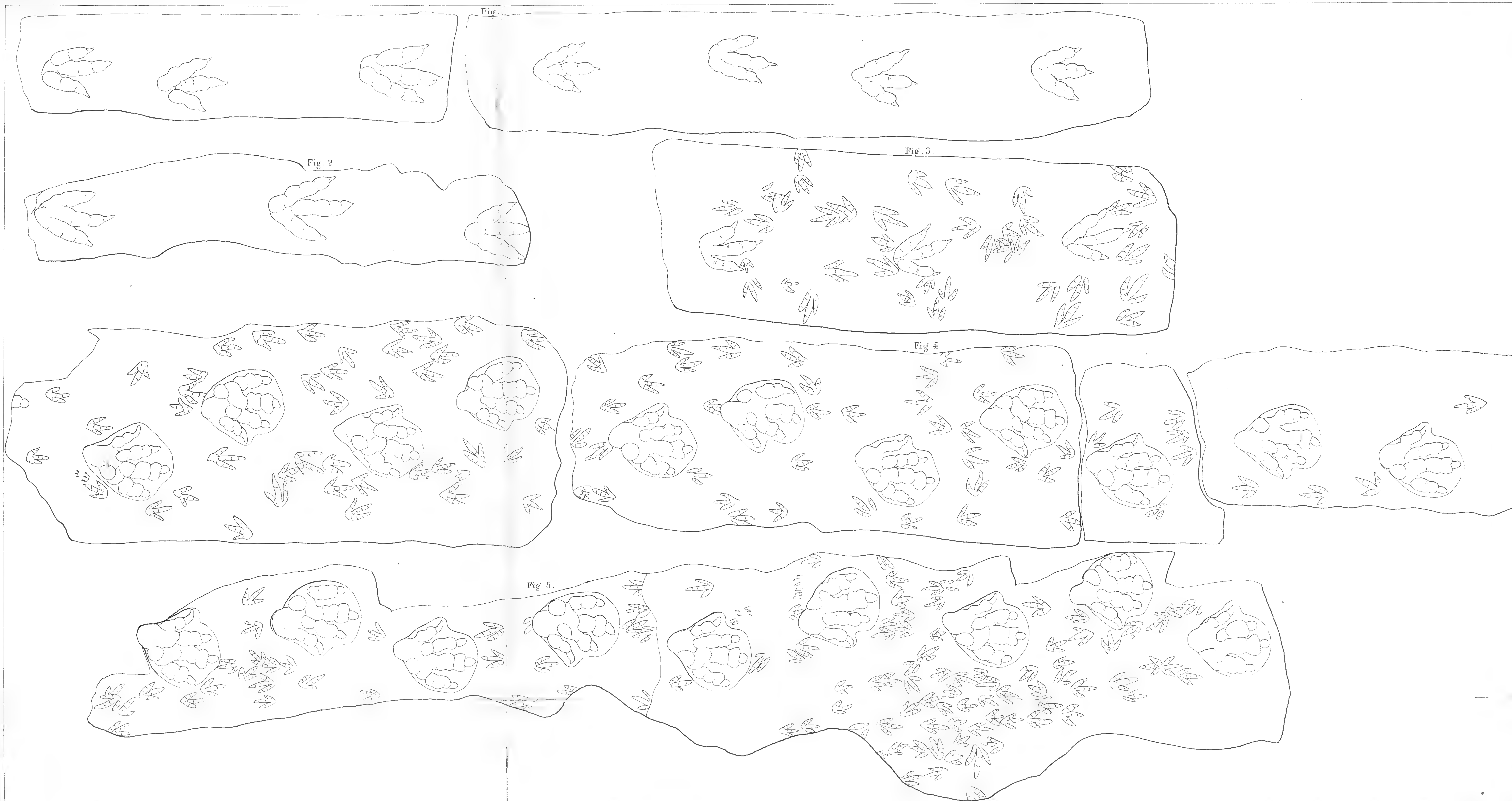


Track of a boy and bird with Rain Drops.

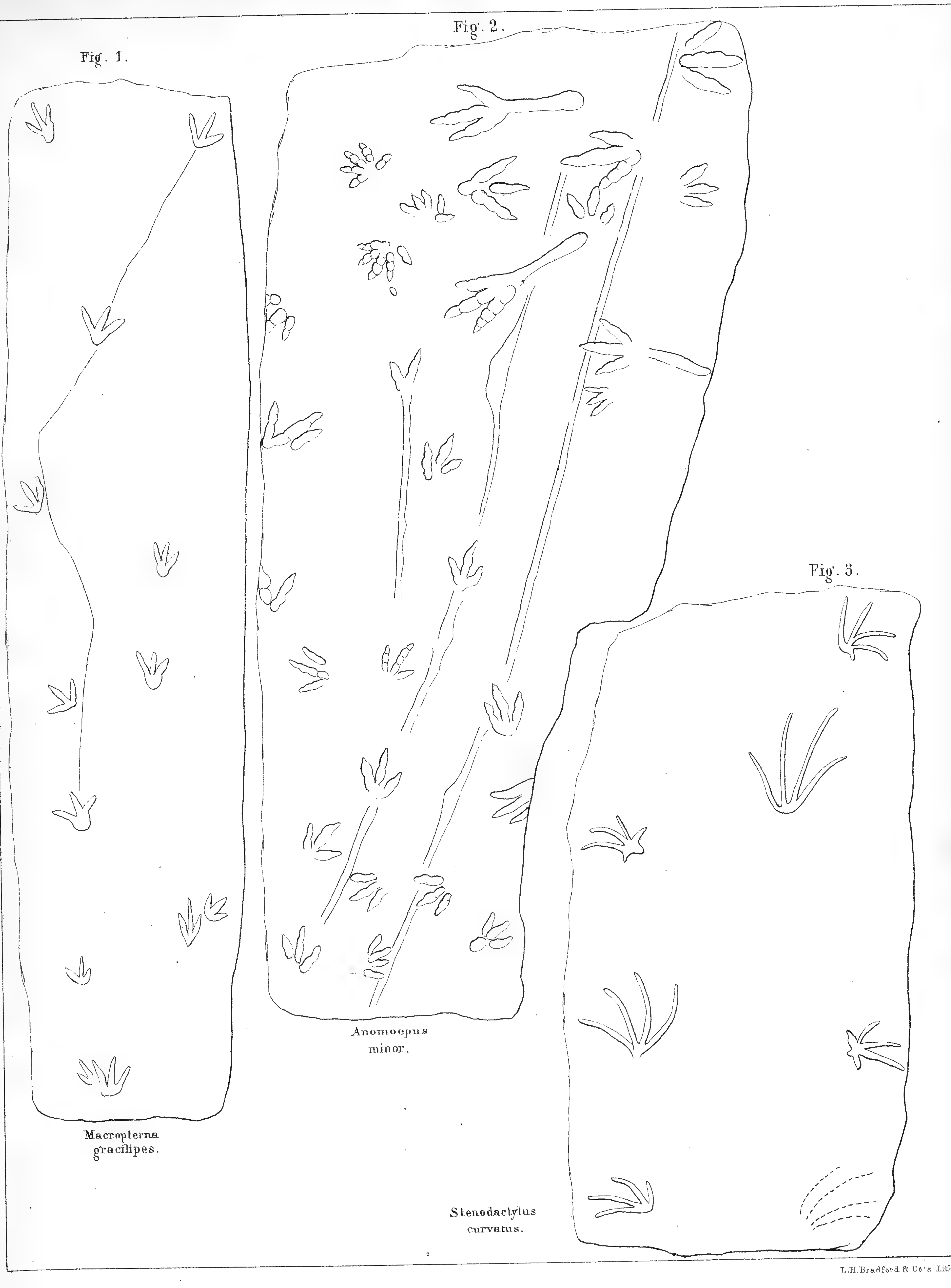
Fig. 2.

Tracks of a bird and a frog.

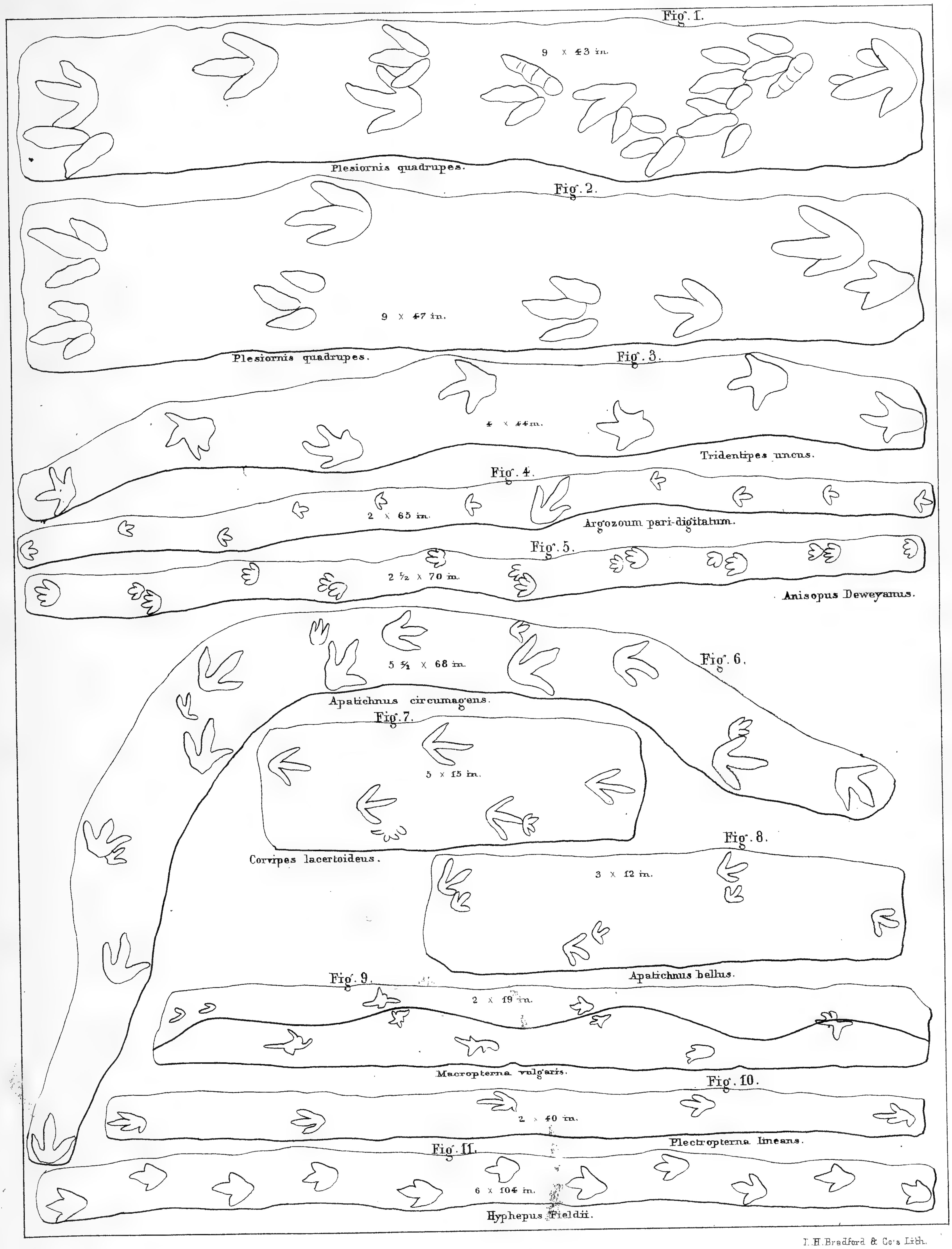
J. H. Bradford & Co. lith.



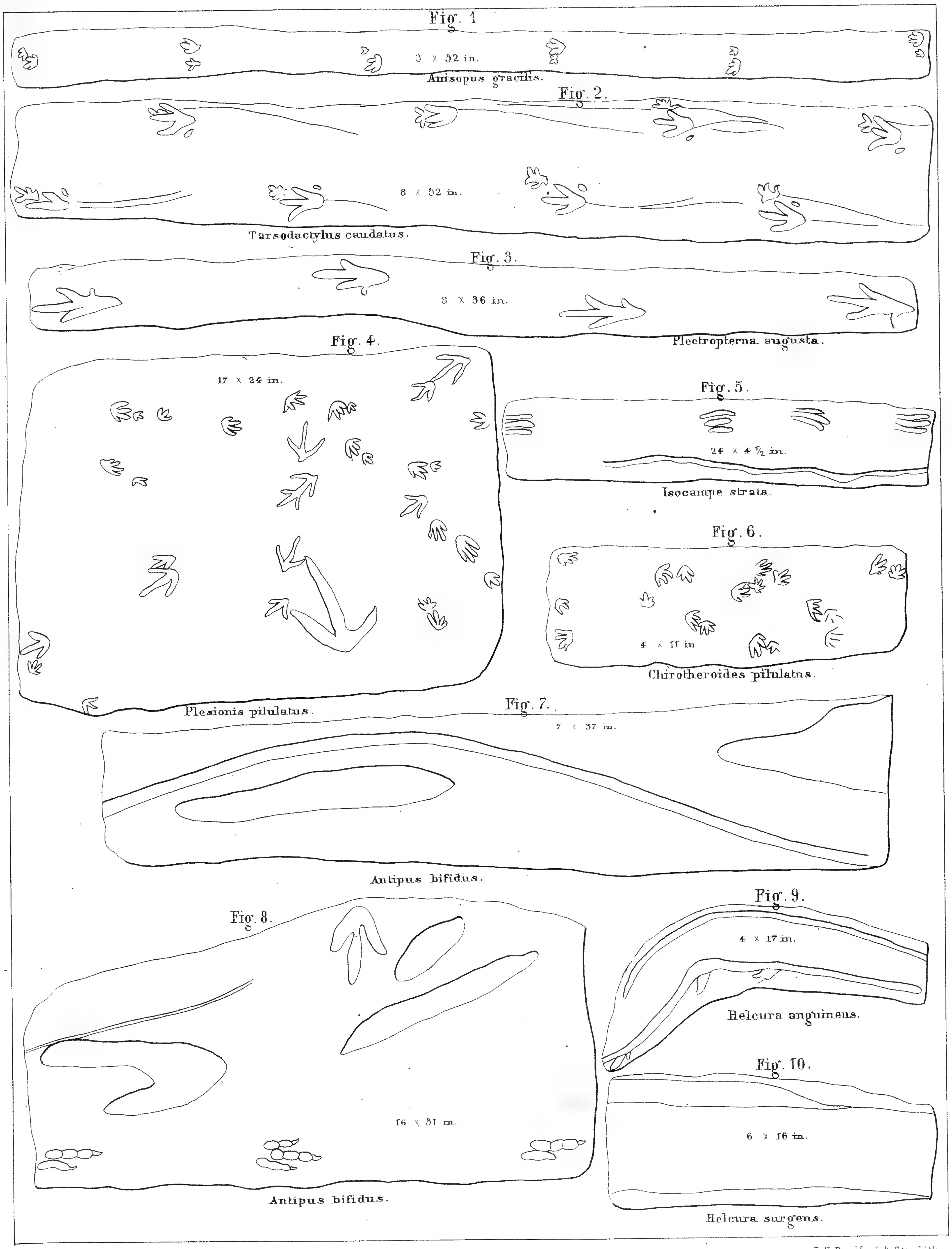
J. H. Bradford & Co's Lith.



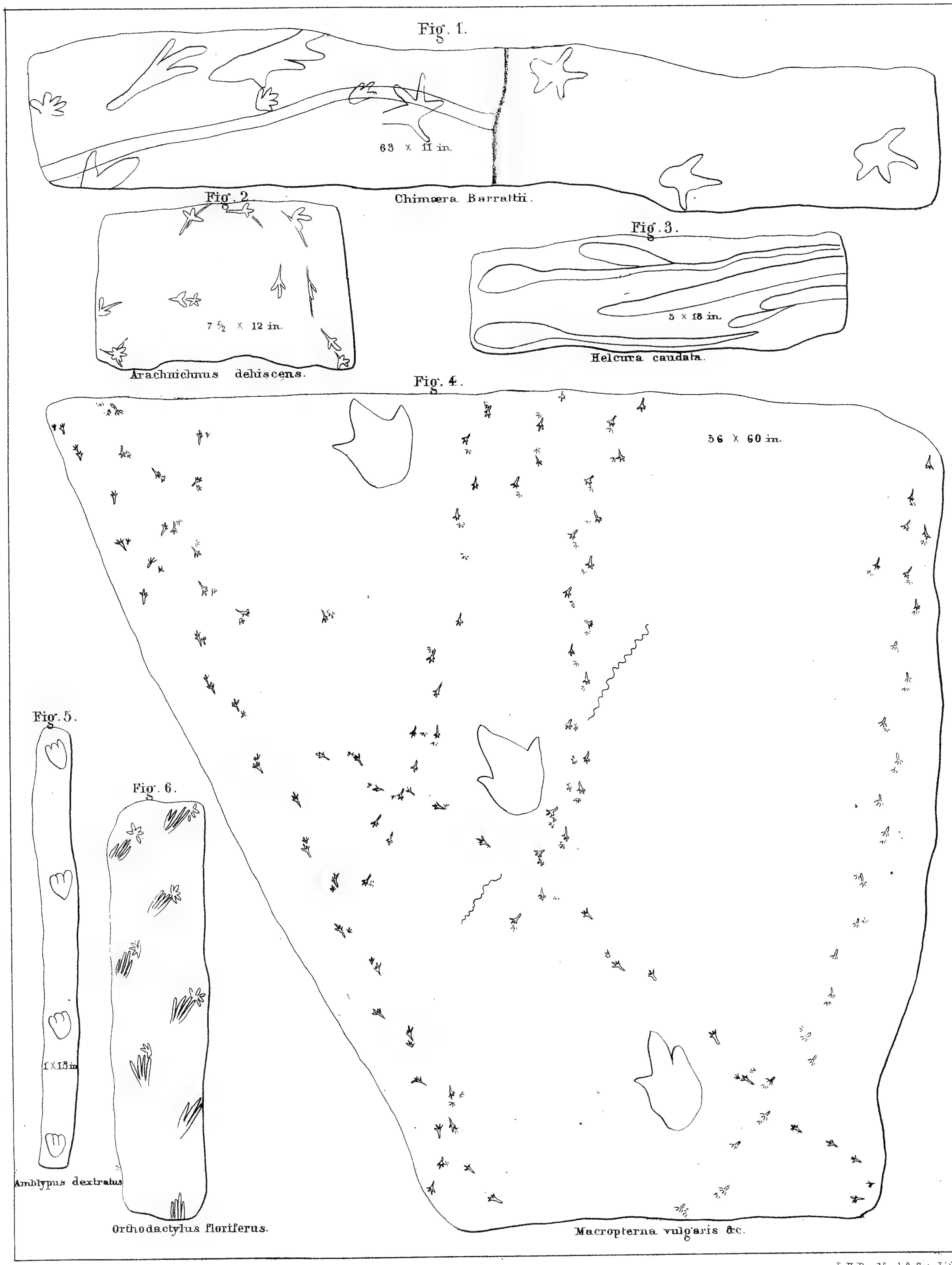
L.H. Bradford & Co's Lith.



J. H. Bradford & Co's Lith.



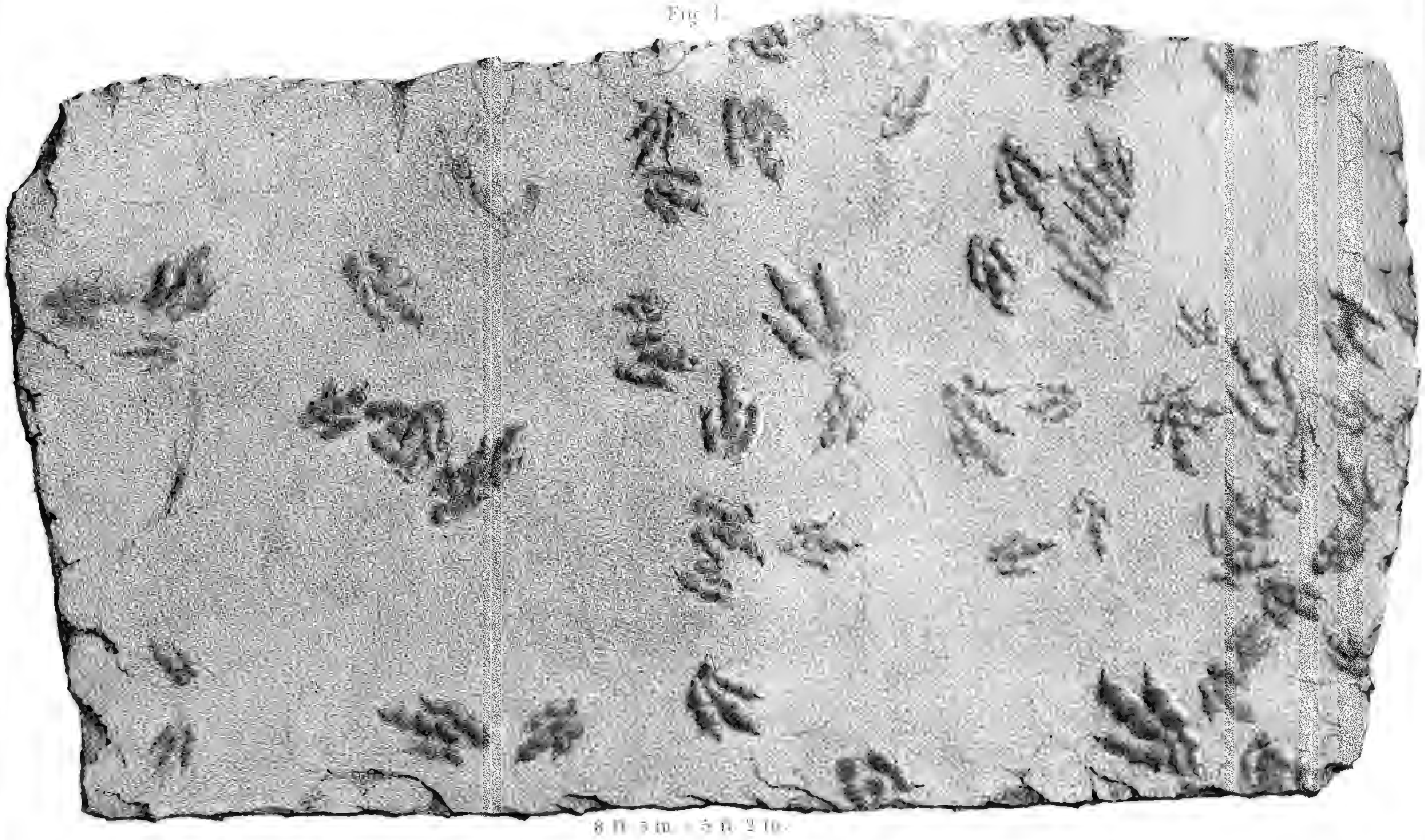
J. H. Bradford & Co's Lith.



J. H. Bradford & Co's Lith.

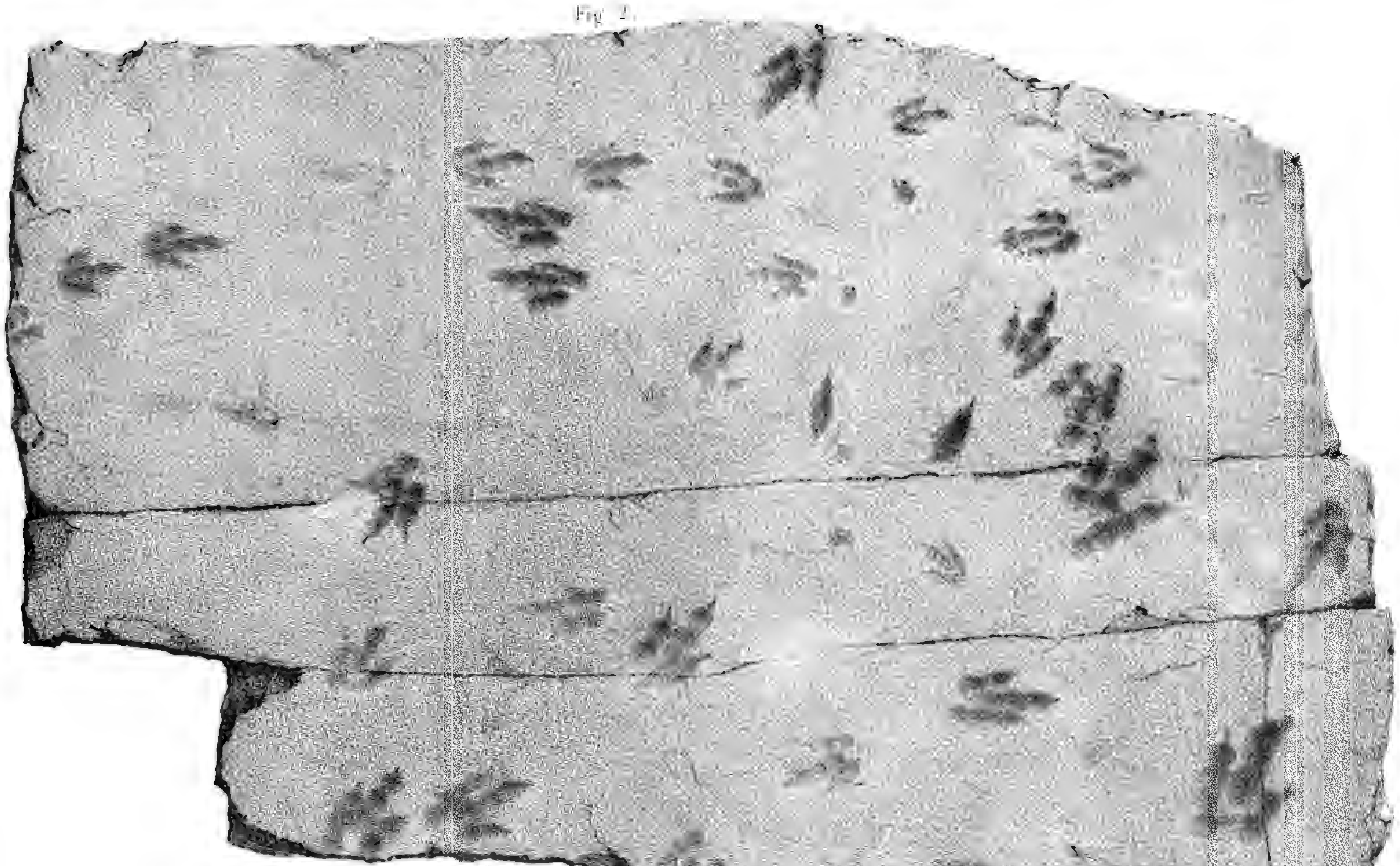
Pl. XX

Fig. 1.



8 ft. 3 in. × 5 ft. 2 in.

Fig. 2.



8 ft. 4 in. × 7 ft. 6 in.

Fig. 1

7 ft. 3 × 7 ft.

Fig. 2

21 × 16 in.

Fig. 3

4 ft. 1 in. × 10 ft.

Fig. 4

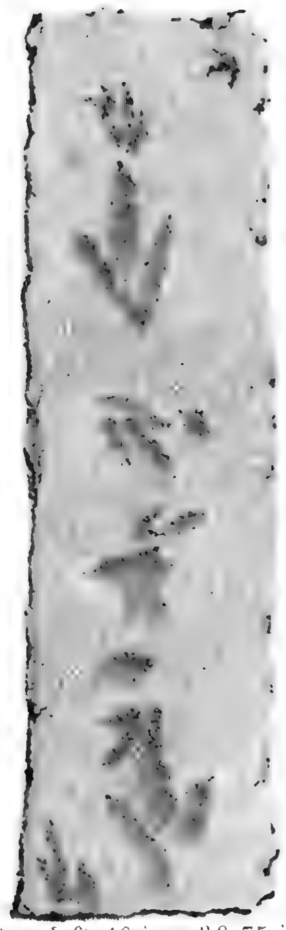
4 ft. × 29 in.

L. H. Bradford & Co.

Fig. 1

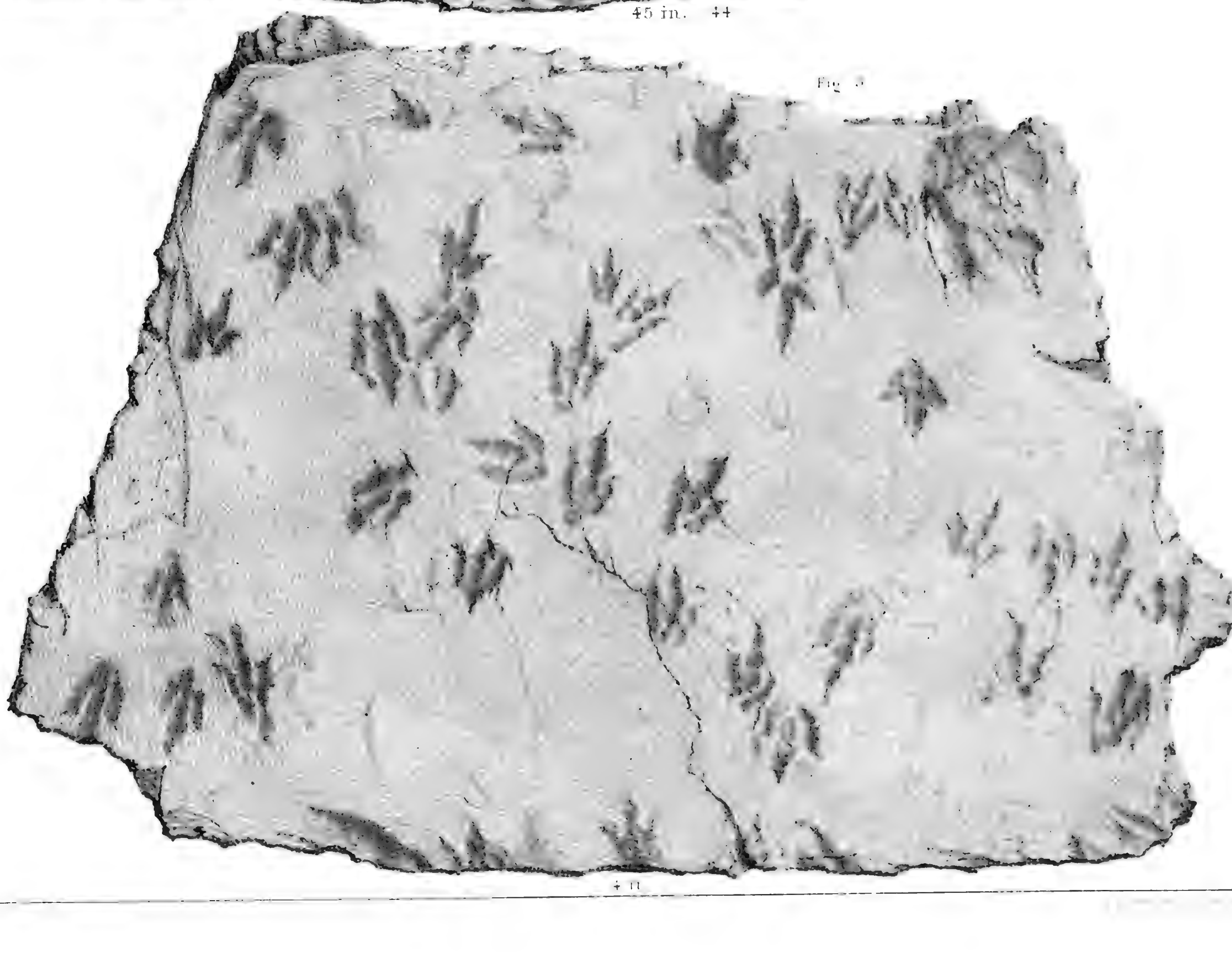
45 in. 44

Fig. 2



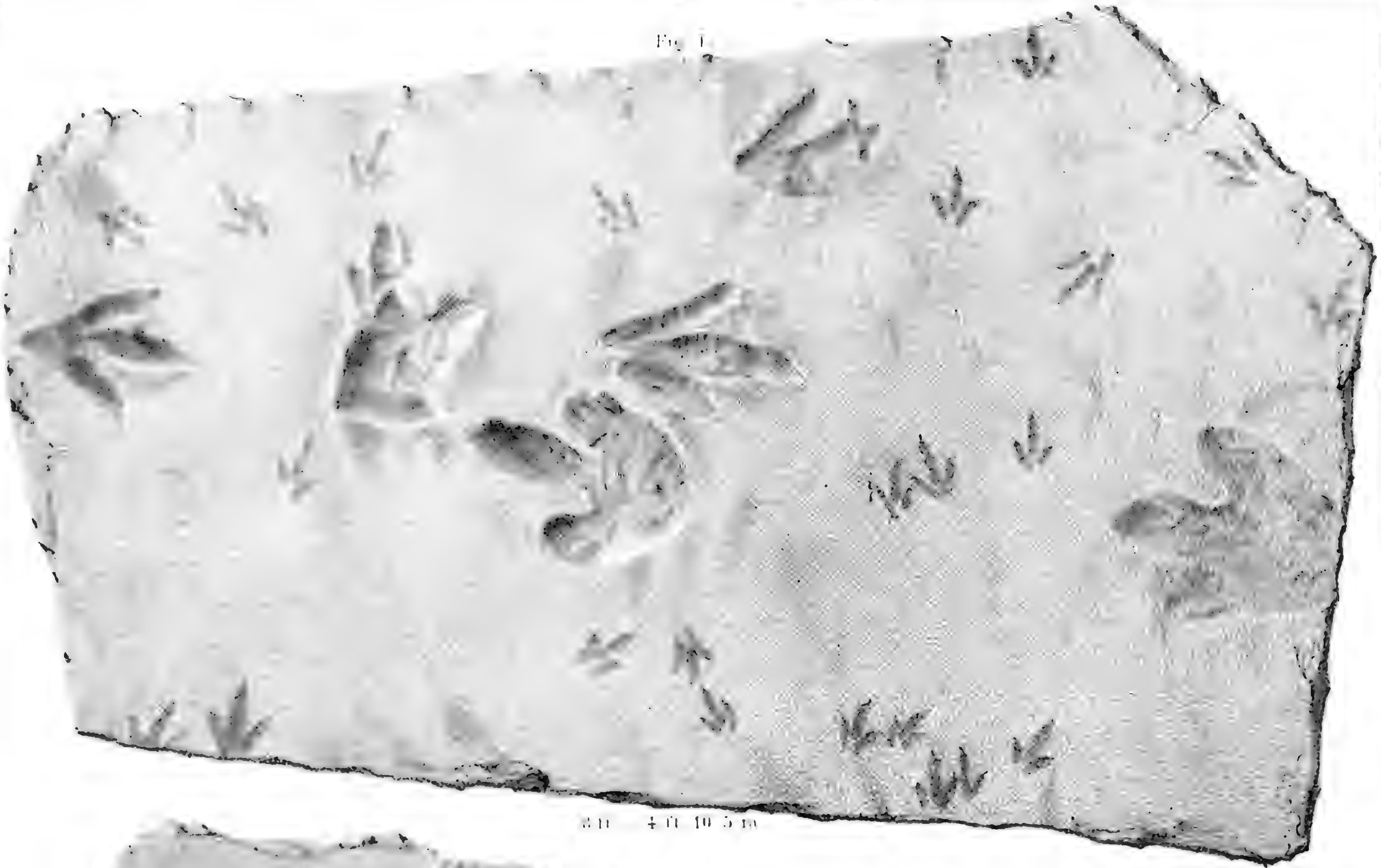
Box 4 ft. 10 in. x 20.75 in.

Fig. 3



4 ft.

Fig. 1.



8 ft. 4 ft. 10.5 in.

Fig. 2.

6 ft. 10 in. 8 ft. 9 in.

J. H. Bufford & Co's Lith.

Fig. 1.

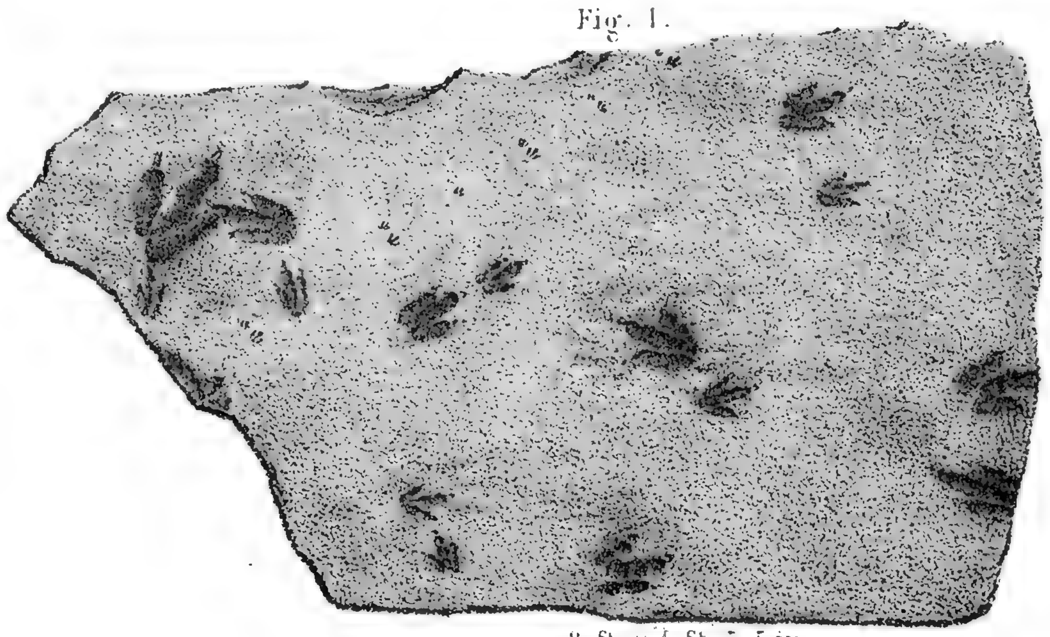
Fig. 2.

Fig. 3.

8 ft. 6 in. × 5 ft. 1 in.

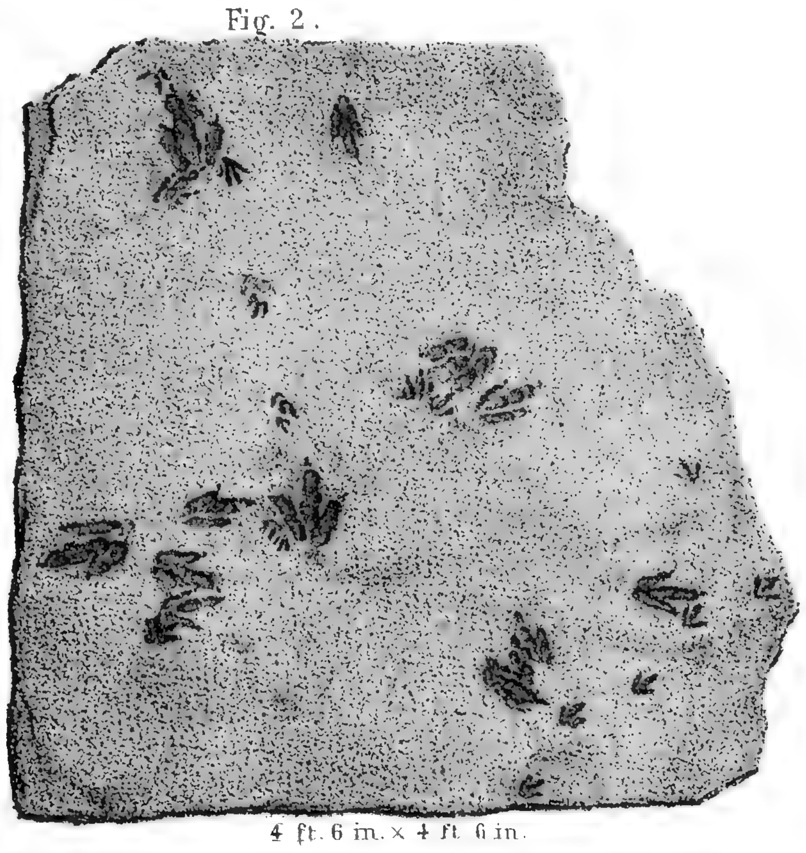
Pl. XLIII

Fig. 1.



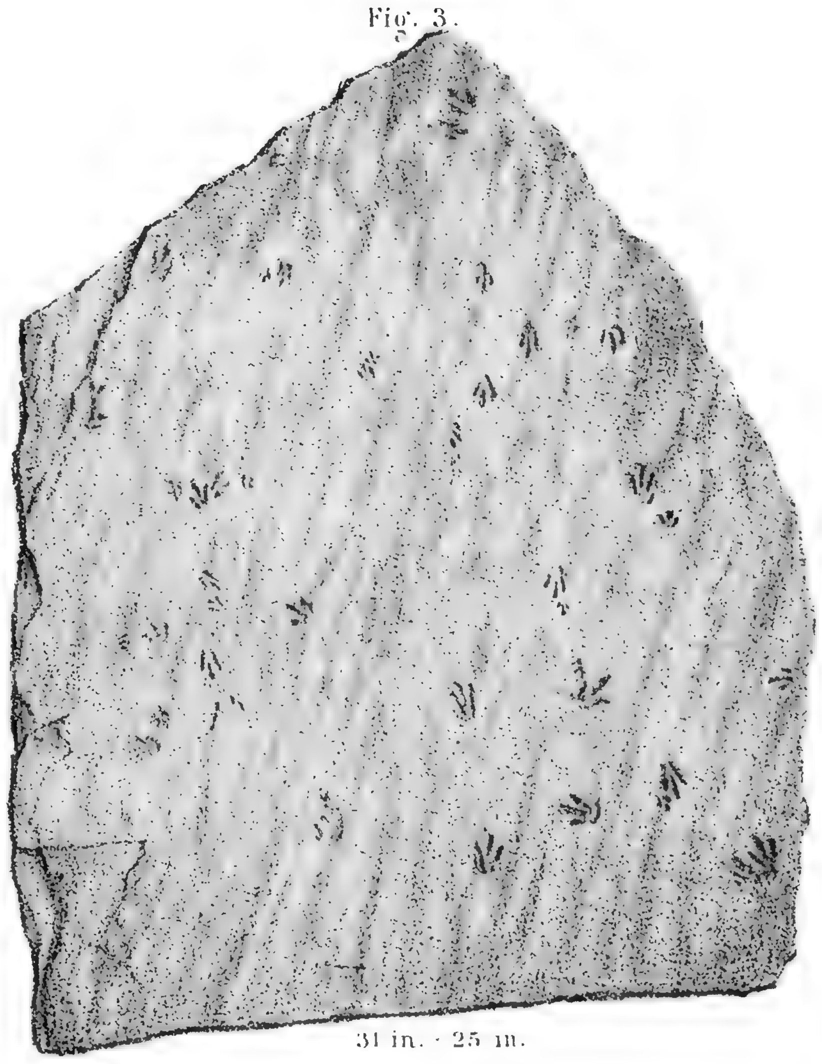
8 ft. × 4 ft. 5.5 in.

Fig. 2.



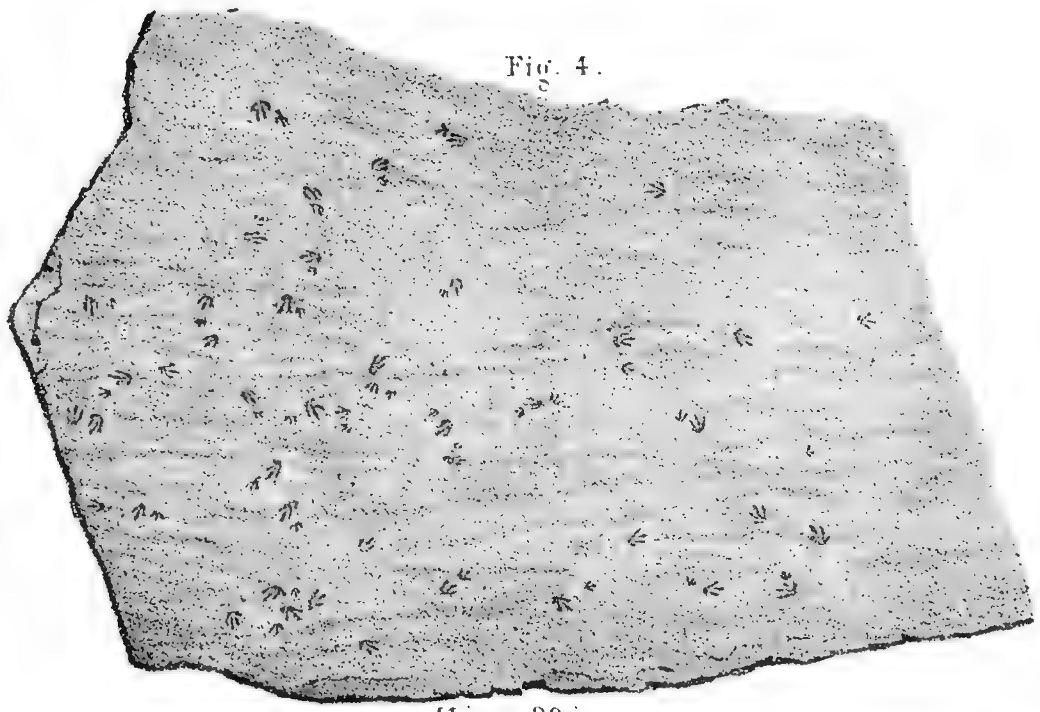
4 ft. 6 in. × 4 ft. 6 in.

Fig. 3.



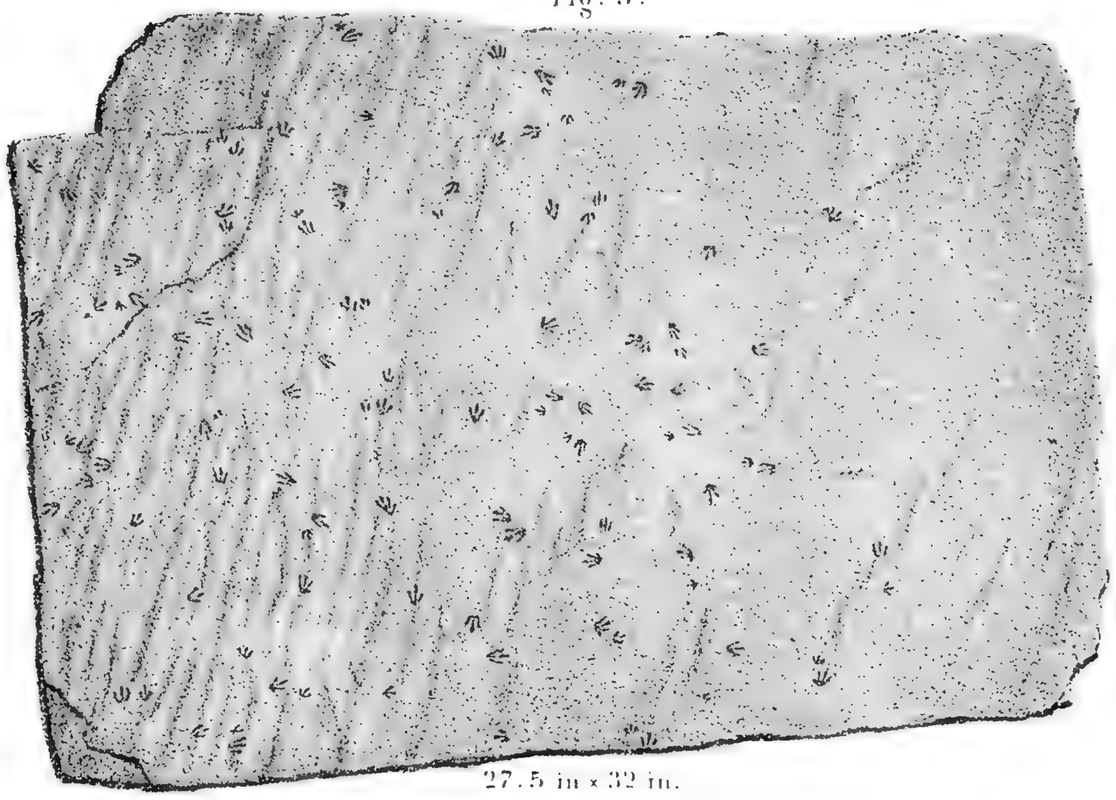
31 in. × 25 in.

Fig. 4.



41 in. × 29 in.

Fig. 5.



27.5 in × 32 in.

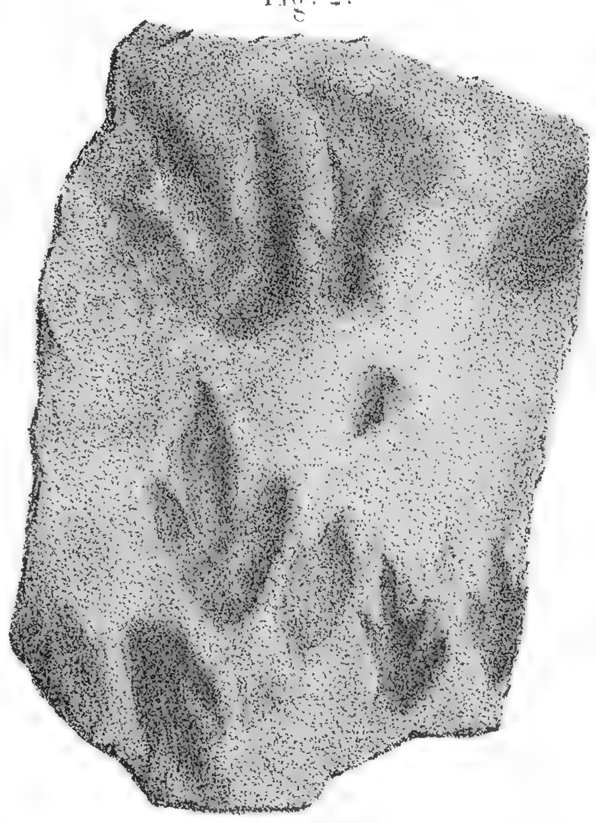
Fig. 6.

21 in × 22 in.

Fig. 1.

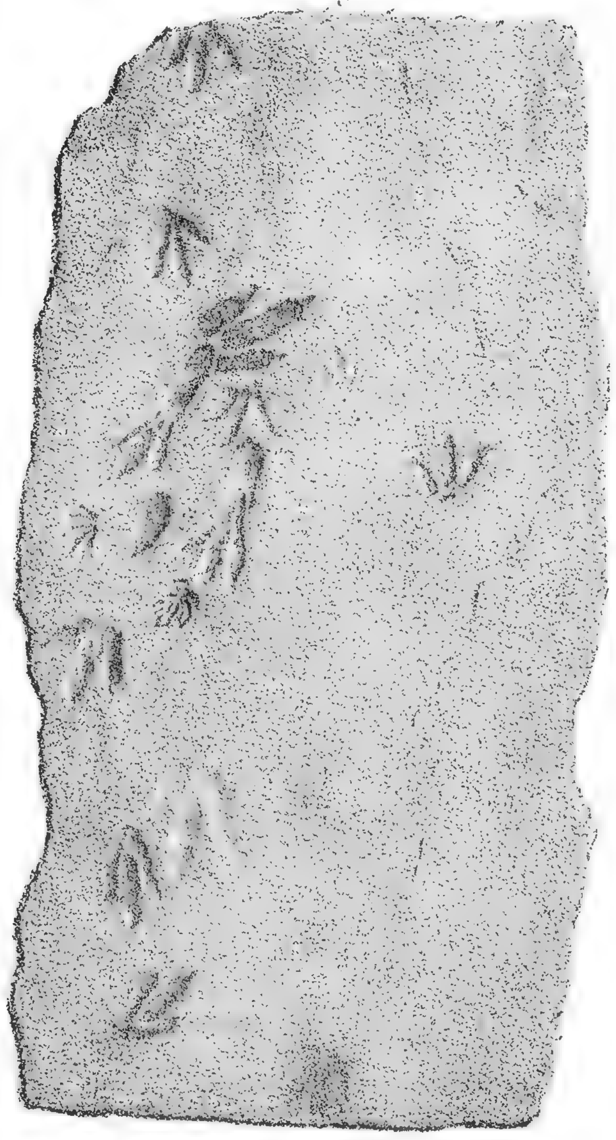
3 ft. 9 in. × 25 in.

Fig. 2.



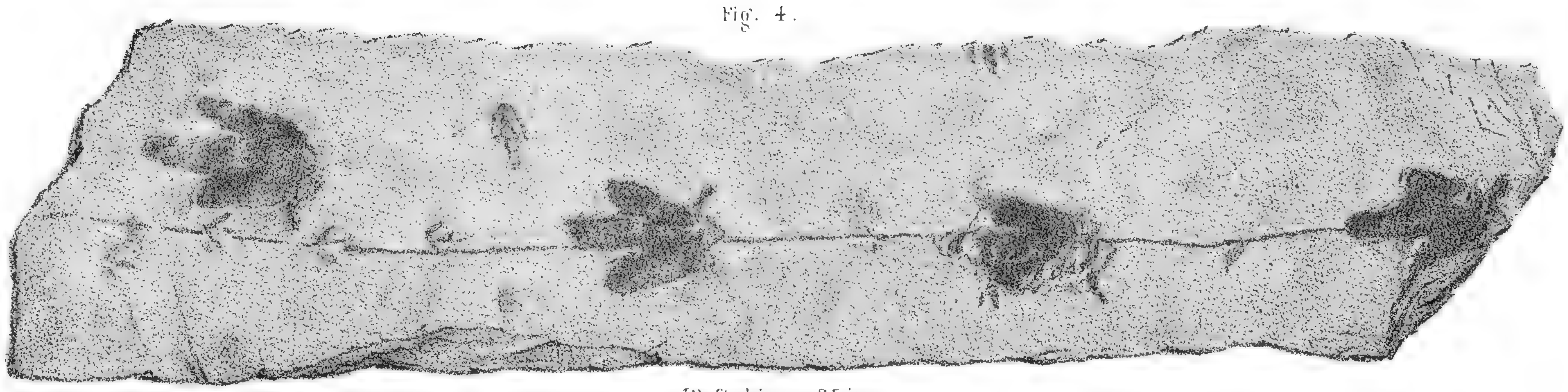
42 in. × 28 in.

Fig. 3.



4 ft. × 2 ft.

Fig. 4.

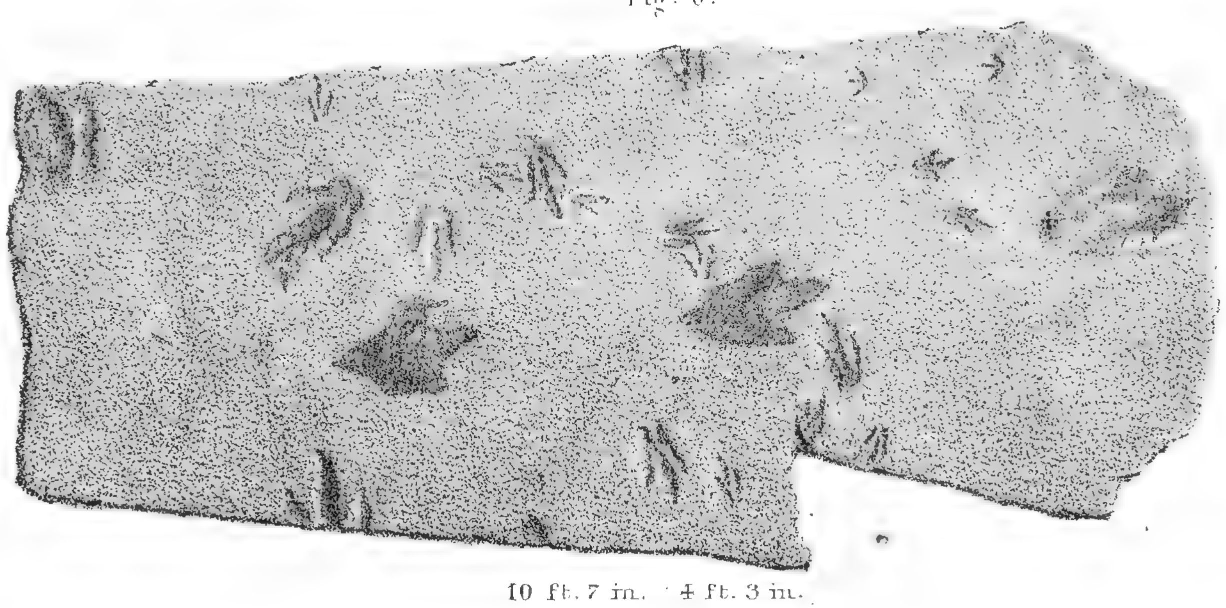


12 ft. 1 in. × 31 in.

Fig. 5.

35 in. × 22 in.

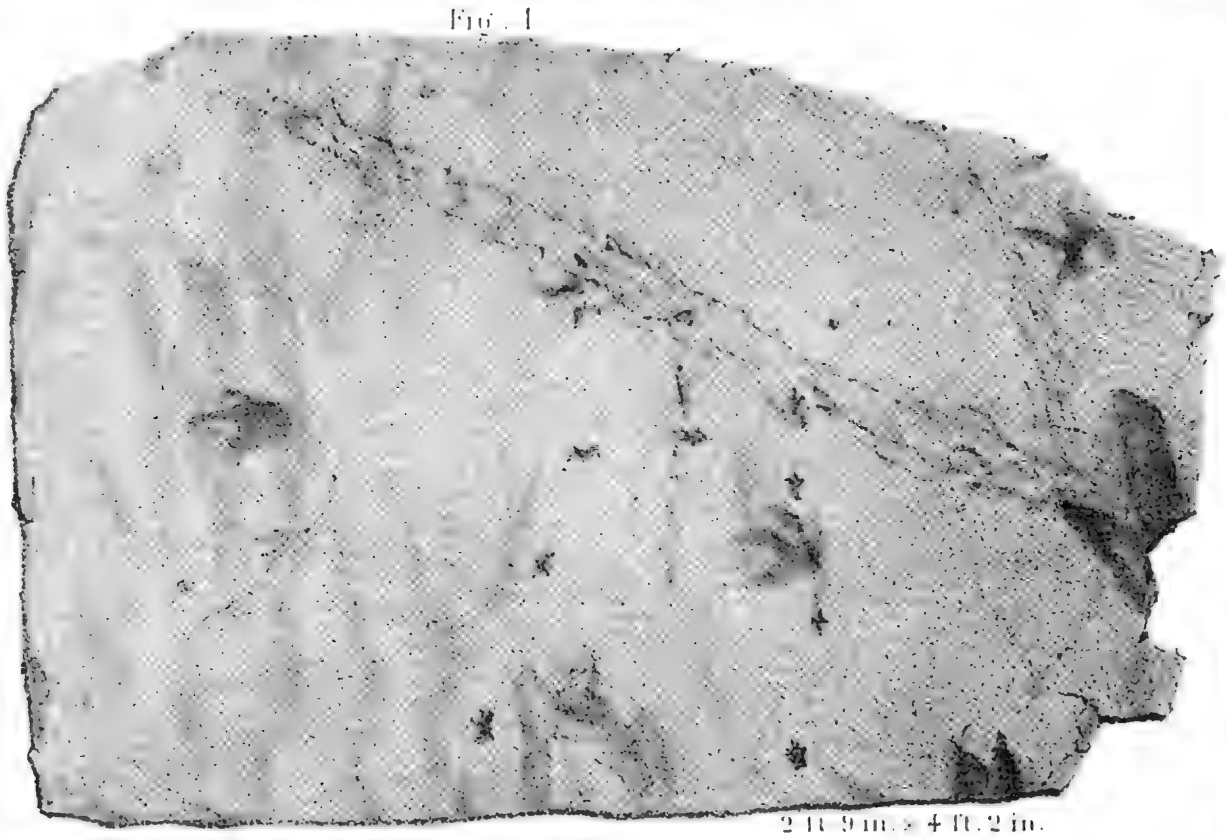
Fig. 6.



10 ft. 7 in. × 4 ft. 3 in.

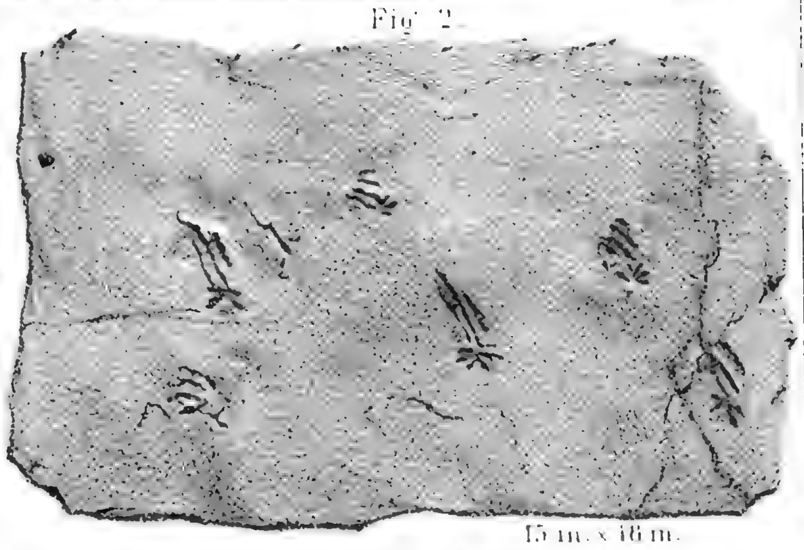
J. H. Bradford & Co's Lith.

Fig. 1.



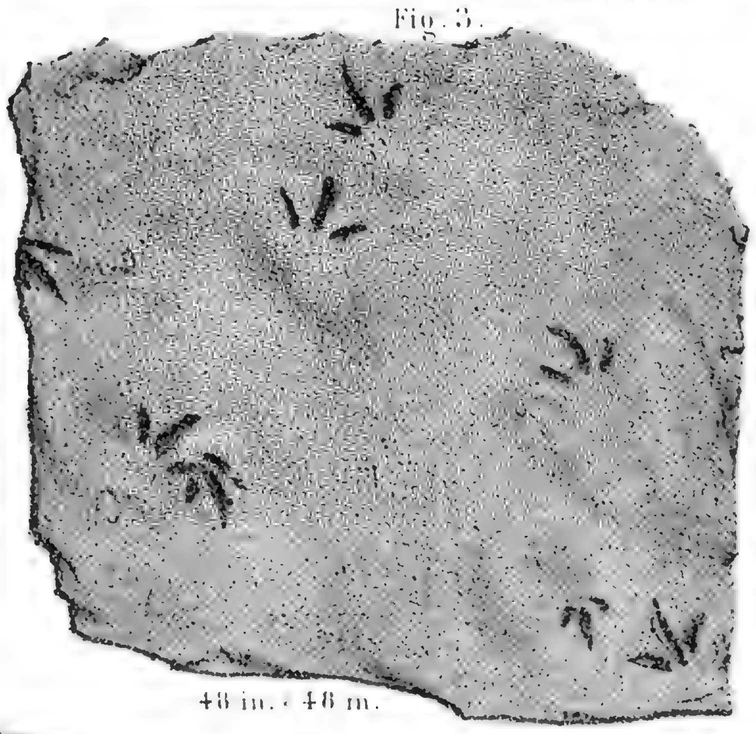
2 ft. 9 in. × 4 ft. 2 in.

Fig. 2.



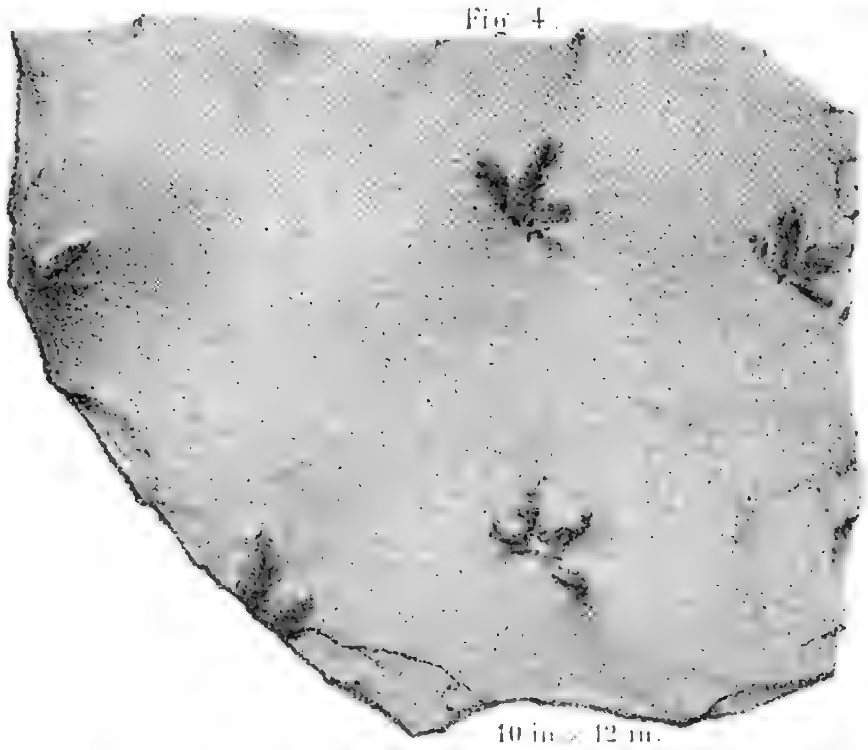
15 in. × 16 in.

Fig. 3.



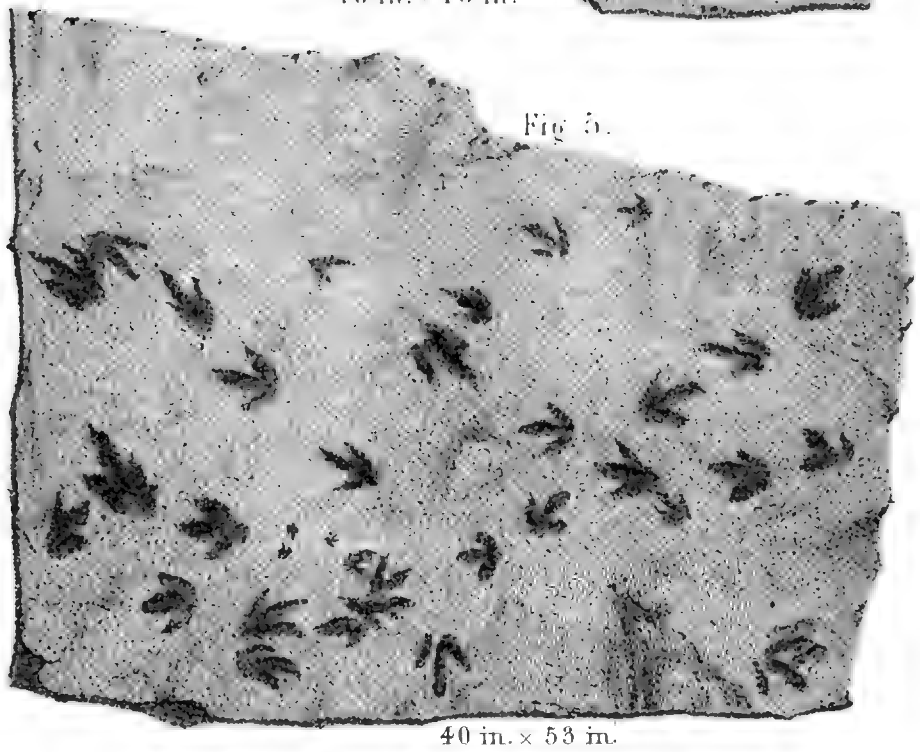
48 in. × 48 in.

Fig. 4.



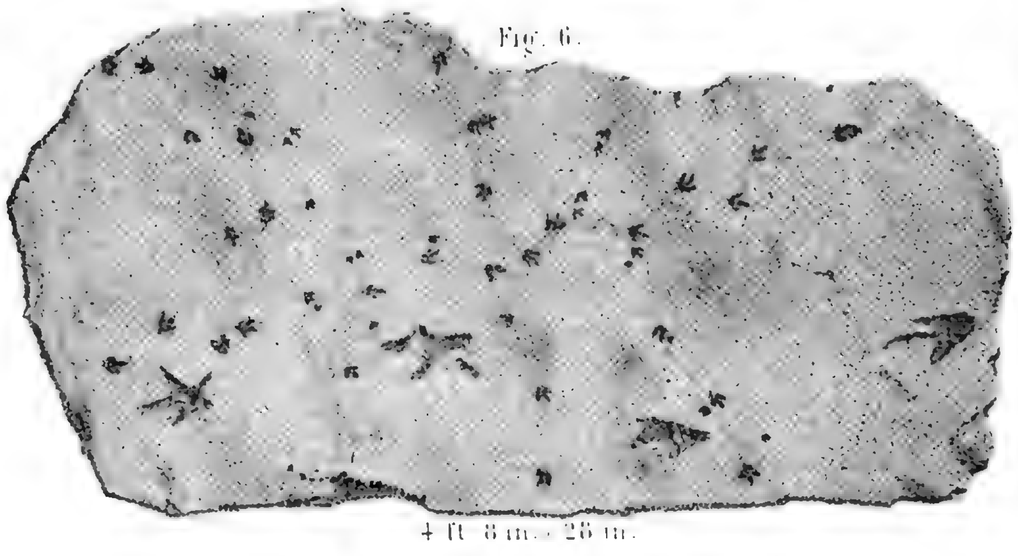
10 in. × 12 in.

Fig. 5.



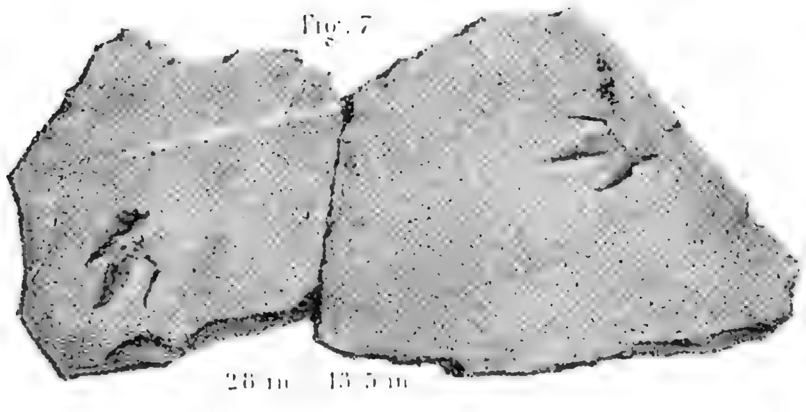
40 in. × 53 in.

Fig. 6.



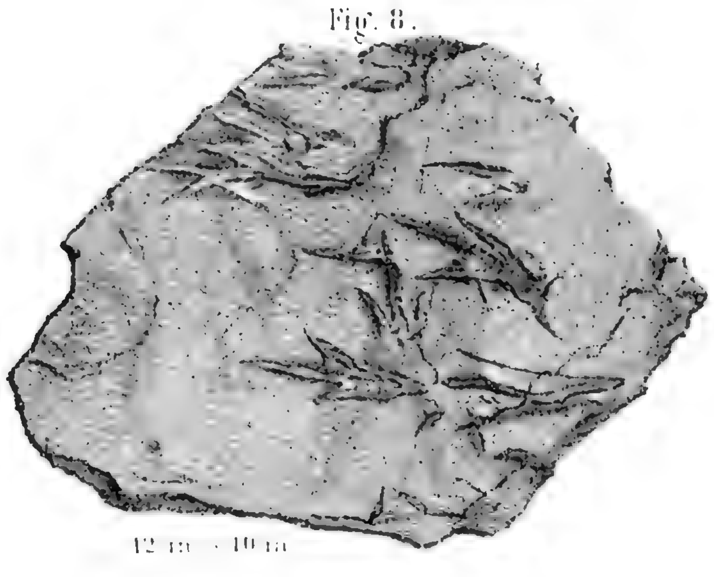
4 ft. 8 in. × 26 in.

Fig. 7.



28 in. × 13.5 in.

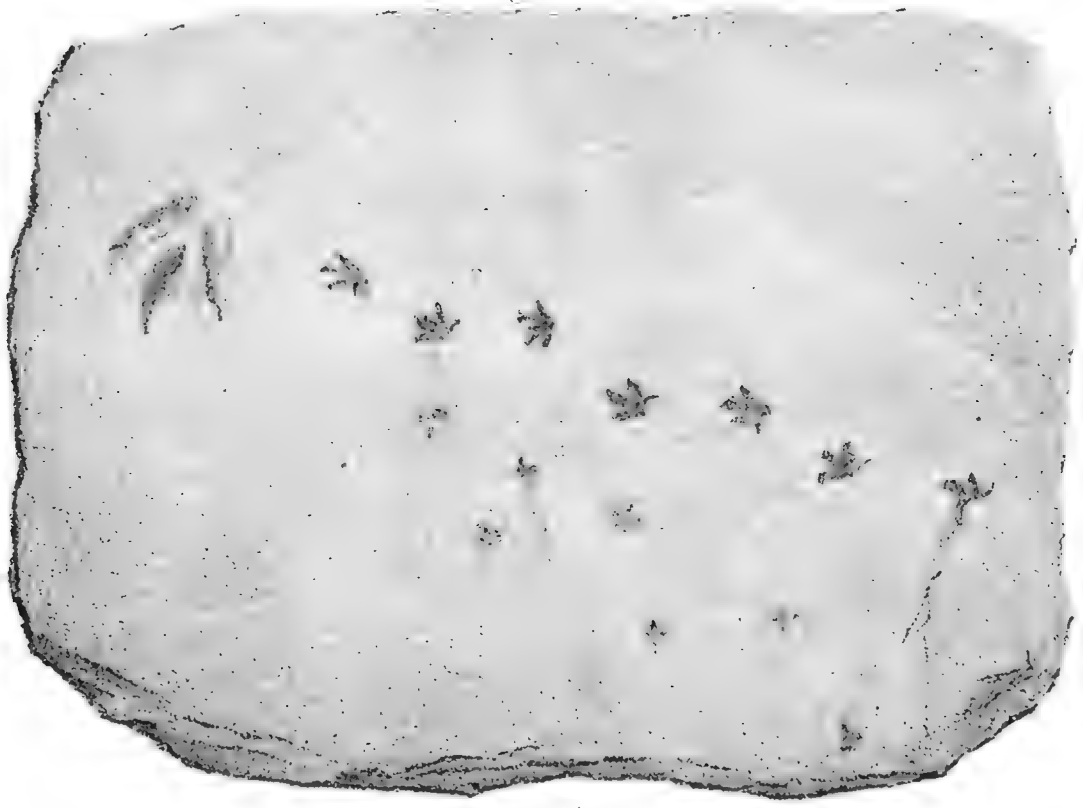
Fig. 8.



12 in. × 10 in.

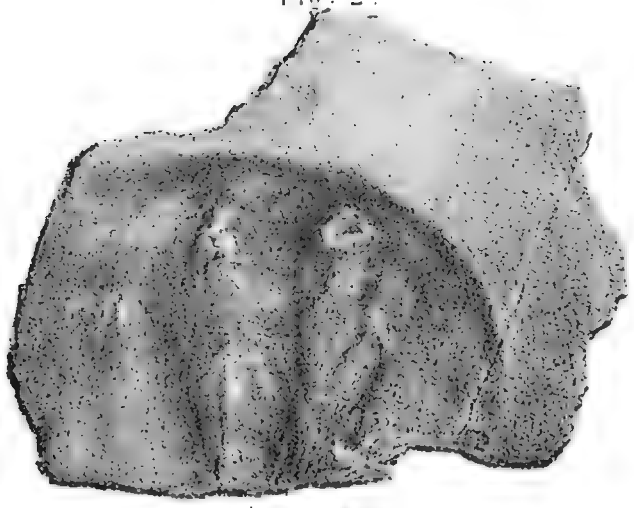
J. H. Bradford & Co's Lith.

Fig. 1.



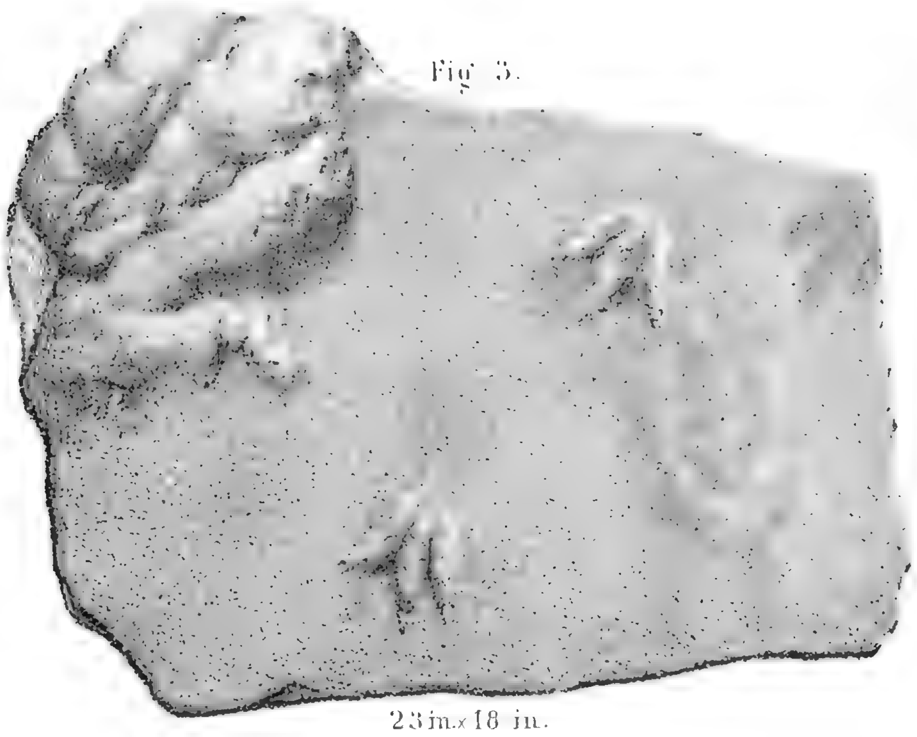
6 ft × 4 ft.

Fig. 2.



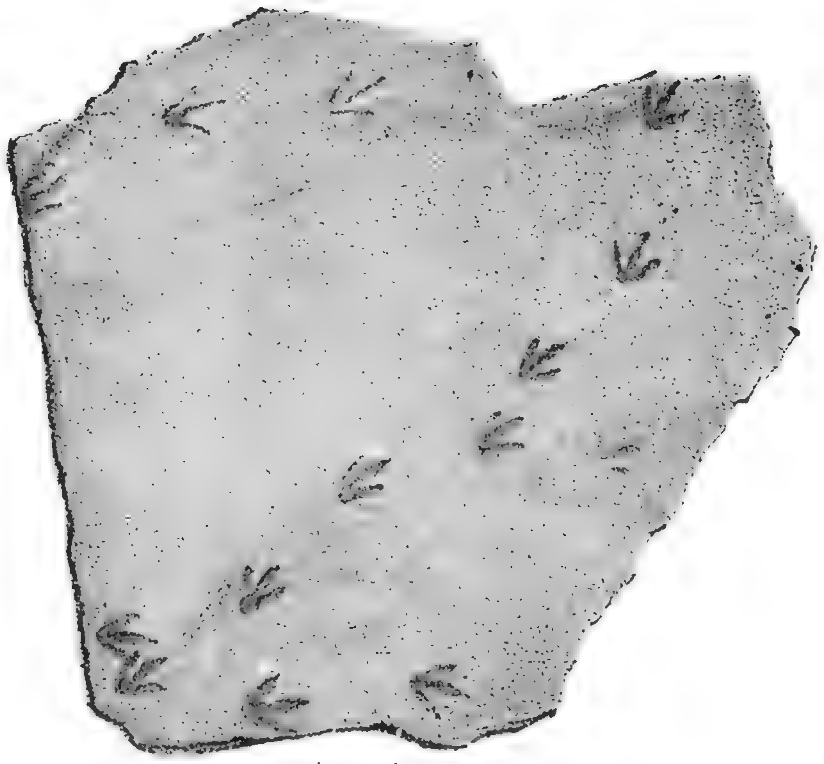
19 in. × 15 in.

Fig. 3.



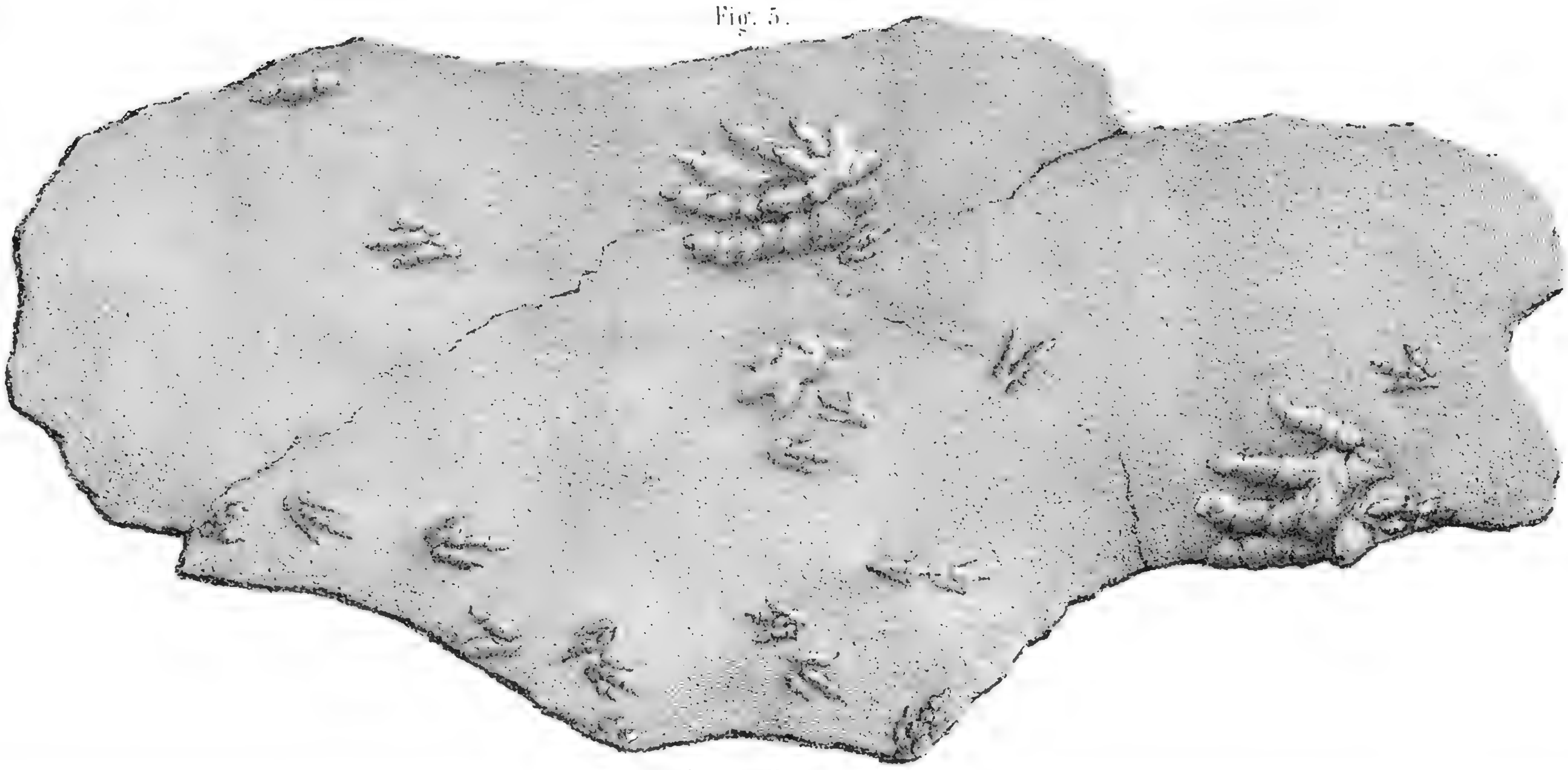
23 in.×18 in.

Fig. 4.



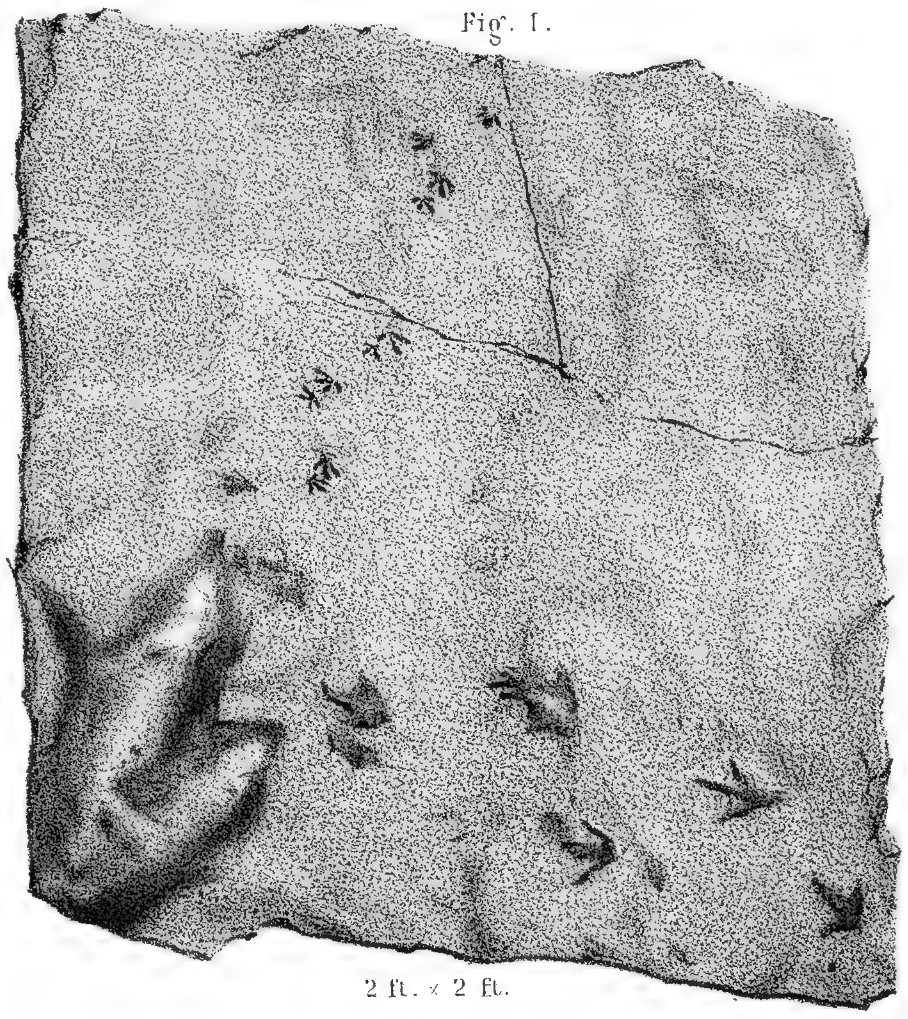
44 in. × 43 in.

Fig. 5.



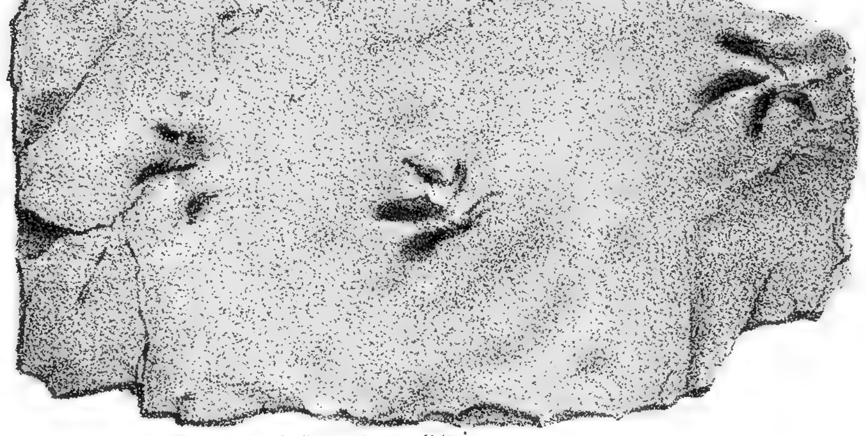
48 in. × 84 in.

Fig. 1.



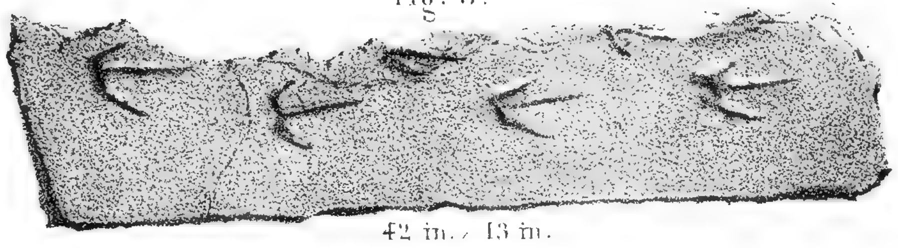
2 ft. × 2 ft.

Fig. 2.



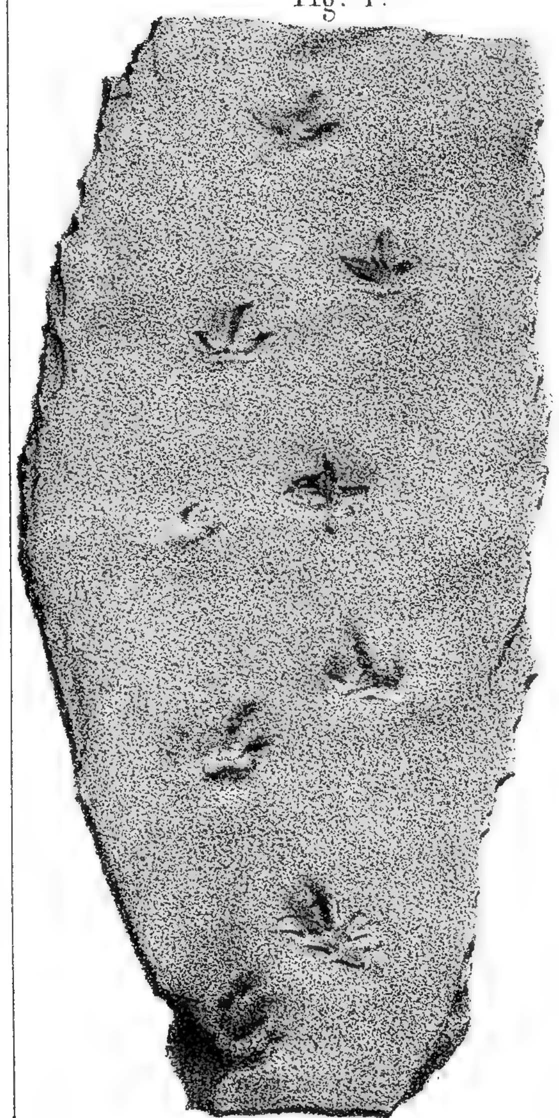
4 ft. 5 in. × 29 in.

Fig. 3.



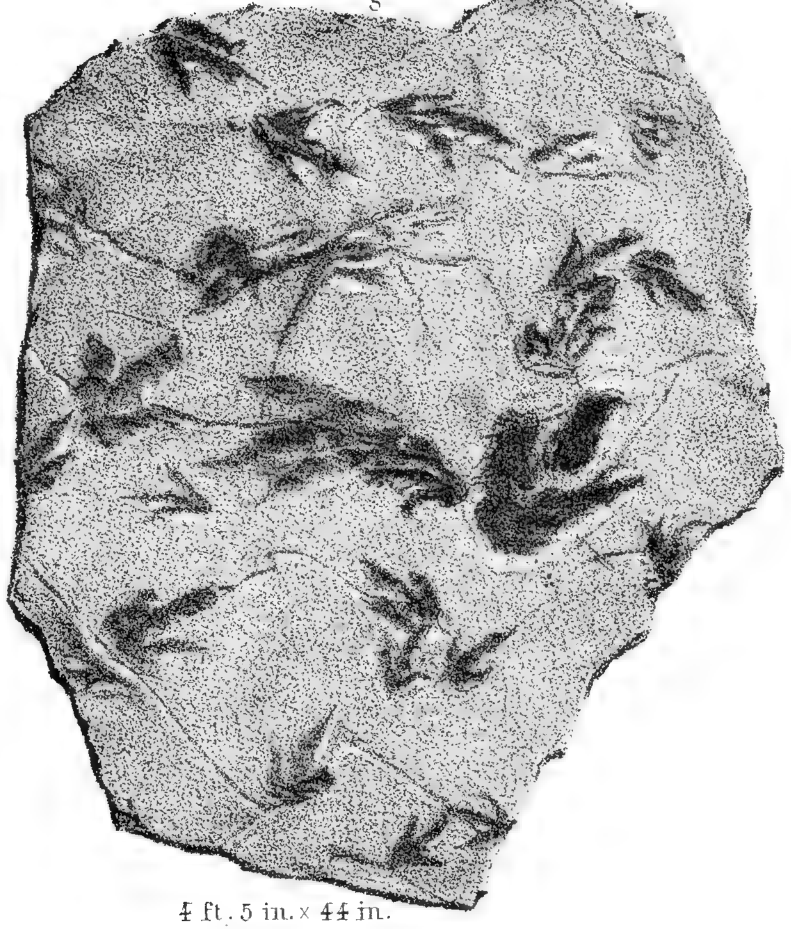
42 in. × 13 in.

Fig. 4.



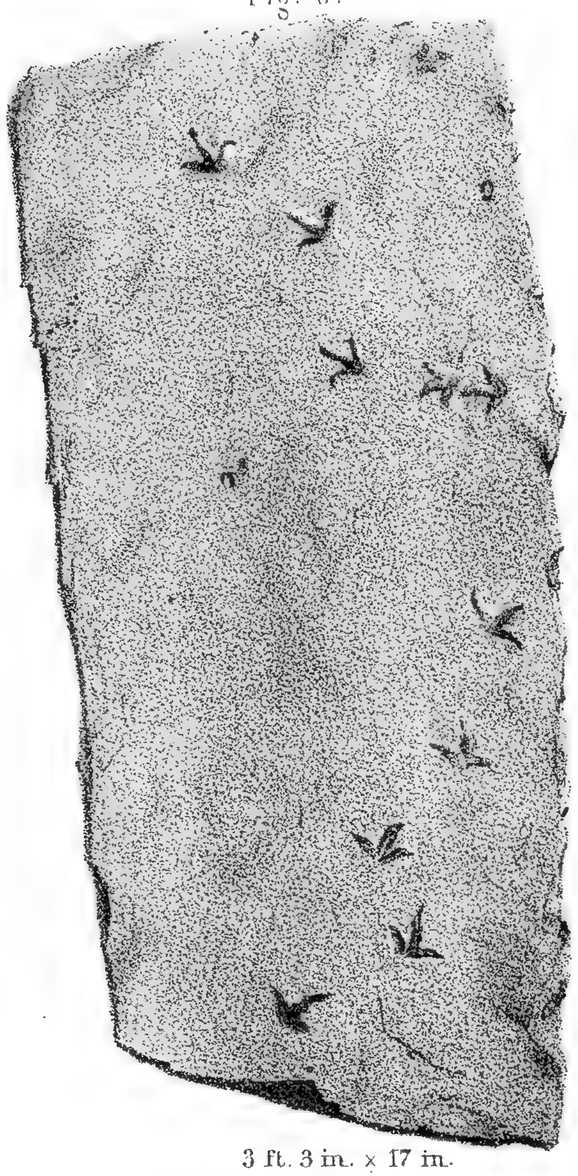
6 ft. 9 in. × 29 in.

Fig. 5.



4 ft. 5 in. × 44 in.

Fig. 6.



3 ft. 3 in. × 17 in.

L.H. Bradford & Co's Lith.

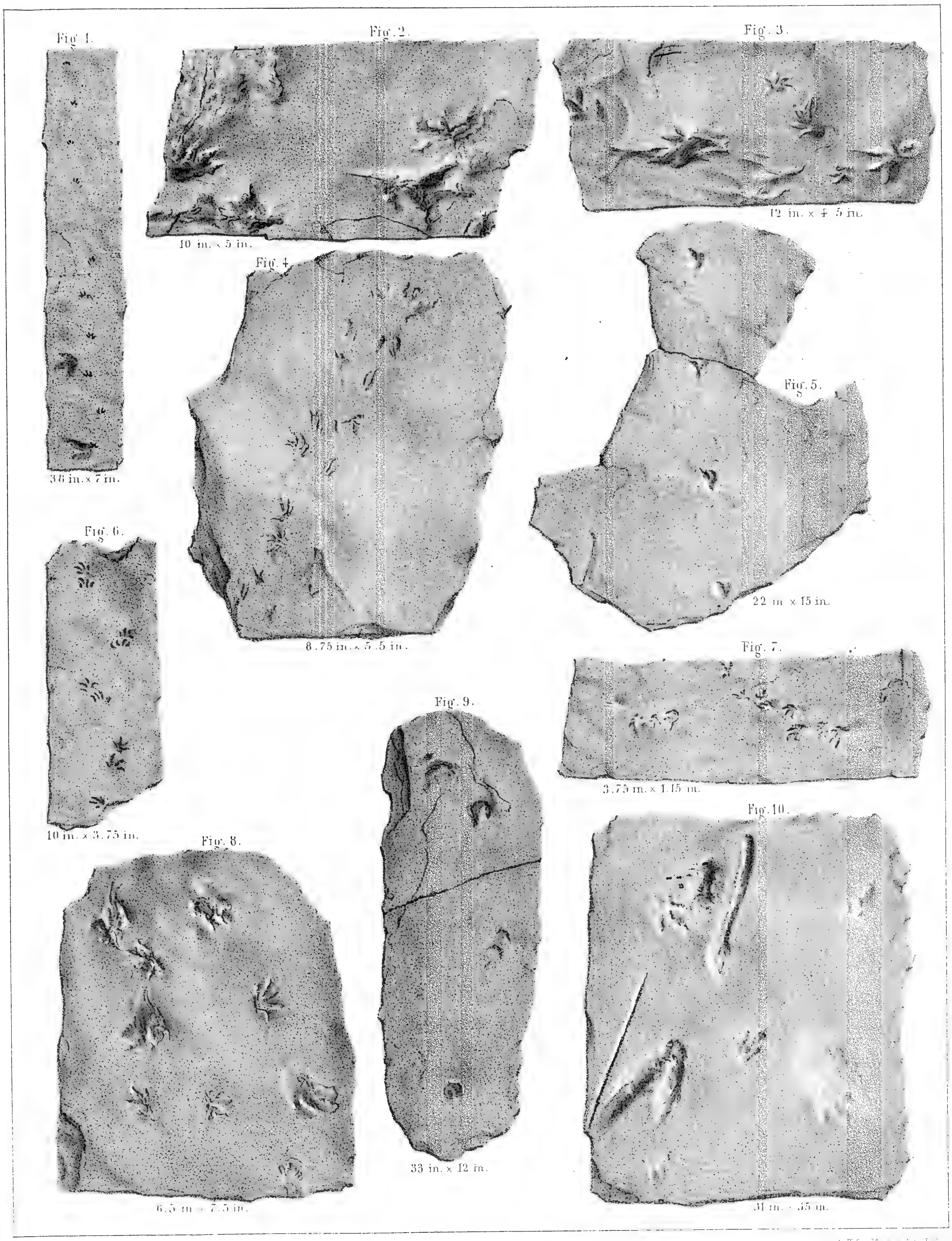
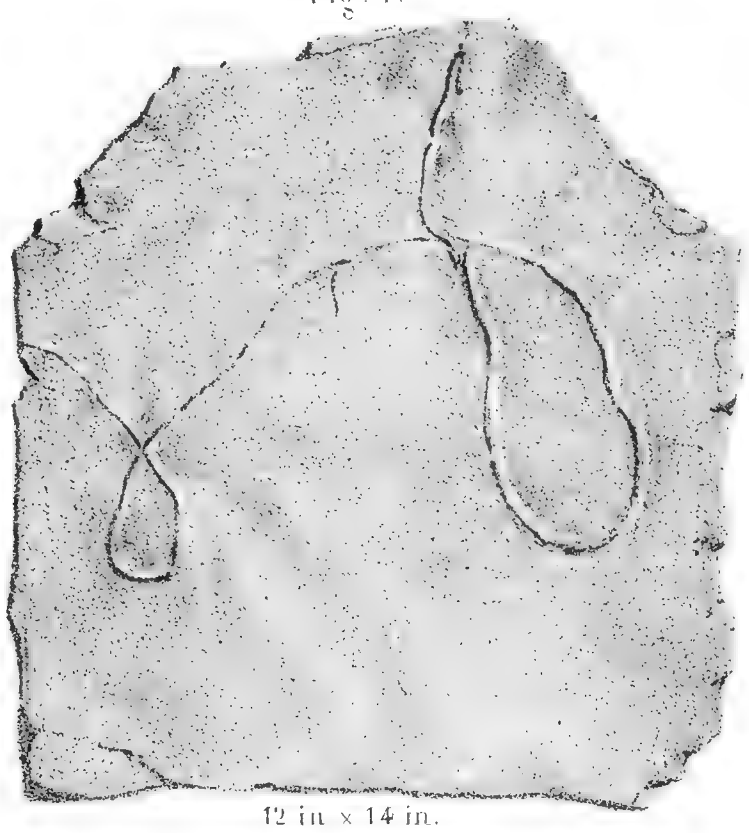


Fig. 1.
36 in. x 7 in.
Fig. 2.
10 in. x 5 in.
Fig. 3.
12 in. x 4.5 in.
Fig. 4.
8.75 in. x 5.5 in.
Fig. 5.
22 in. x 15 in.
Fig. 6.
10 in. x 3.75 in.
Fig. 7.
3.75 in. x 1.15 in.
Fig. 8.
6.5 in. x 7.5 in.
Fig. 9.
33 in. x 12 in.
Fig. 10.
31 in. x 35 in.

Fig. 1.



12 in. x 14 in.

Fig. 2.

23 in. x 20 in.

Fig. 3.

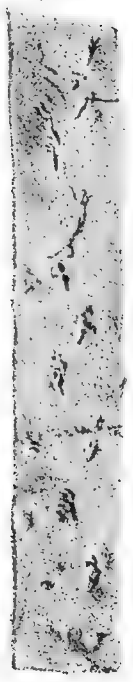
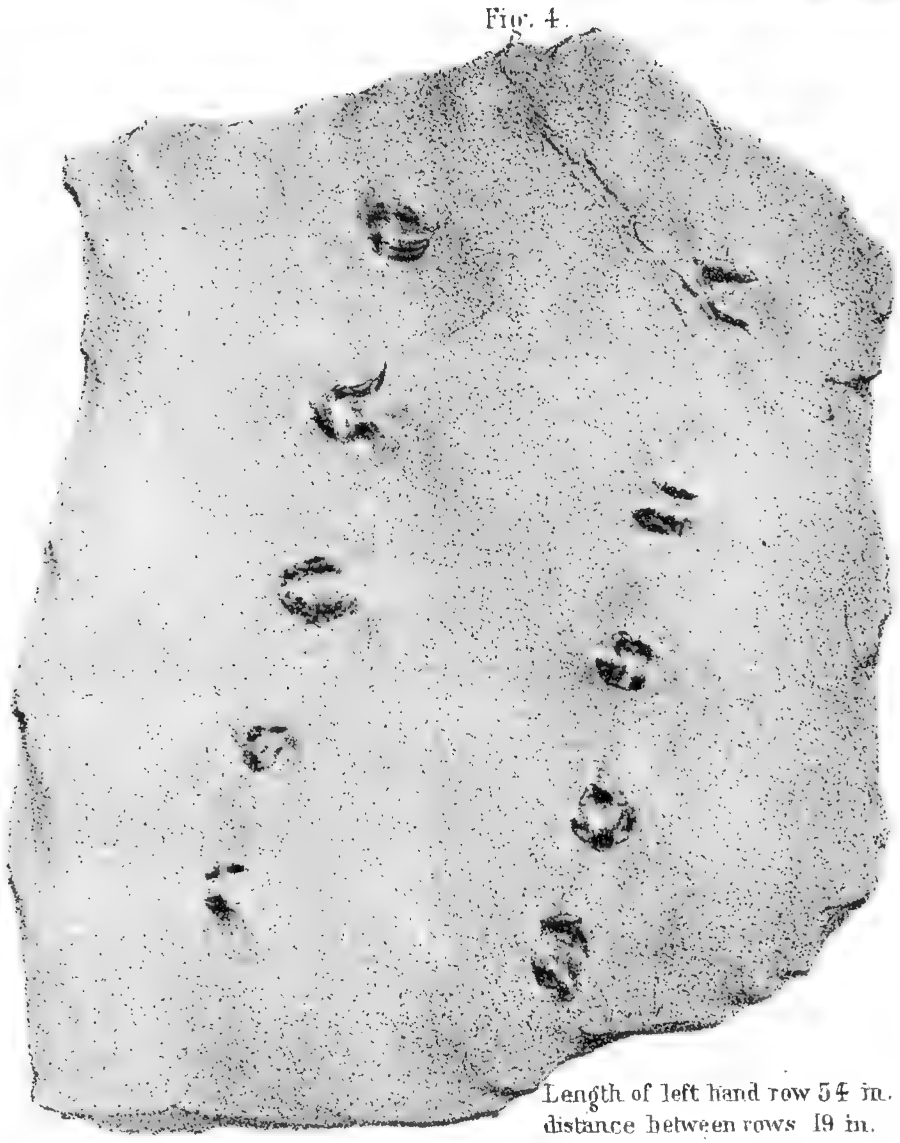
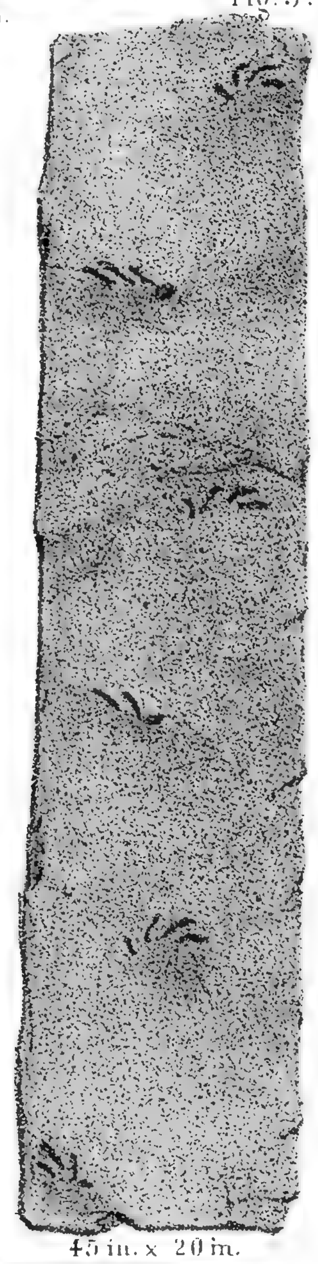


Fig. 4.



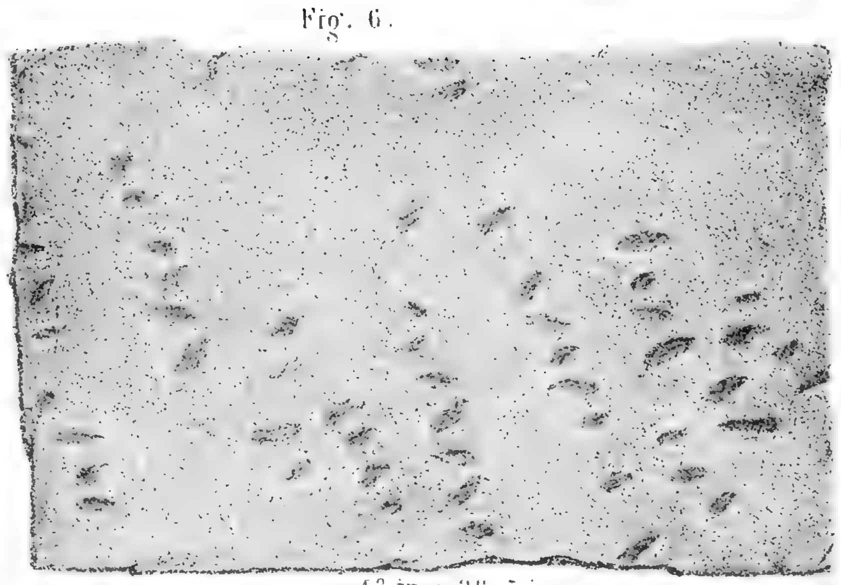
Length of left hand row 54 in.
distance between rows 19 in.

Fig. 5.



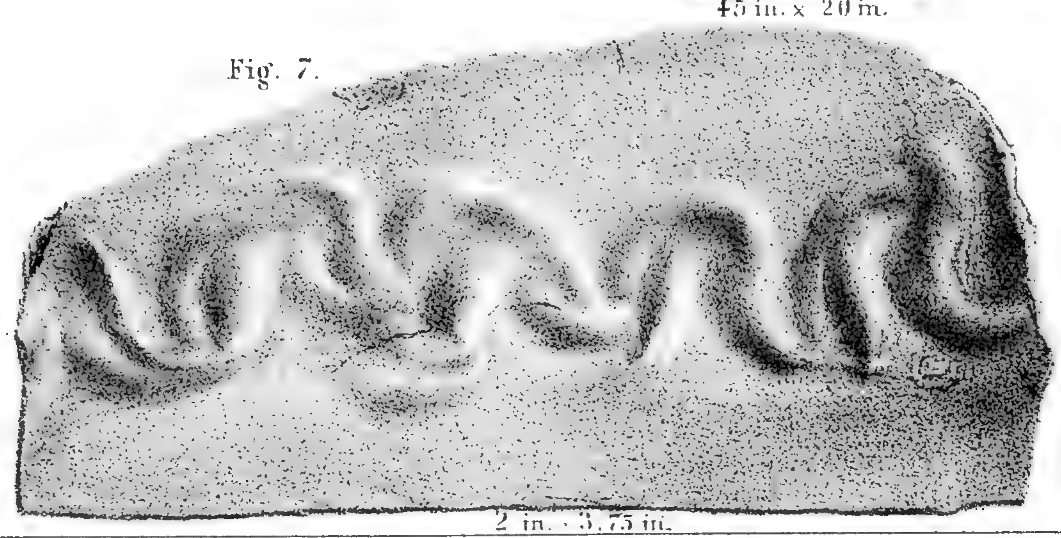
45 in. x 20 in.

Fig. 6.



43 in. x 28.5 in.

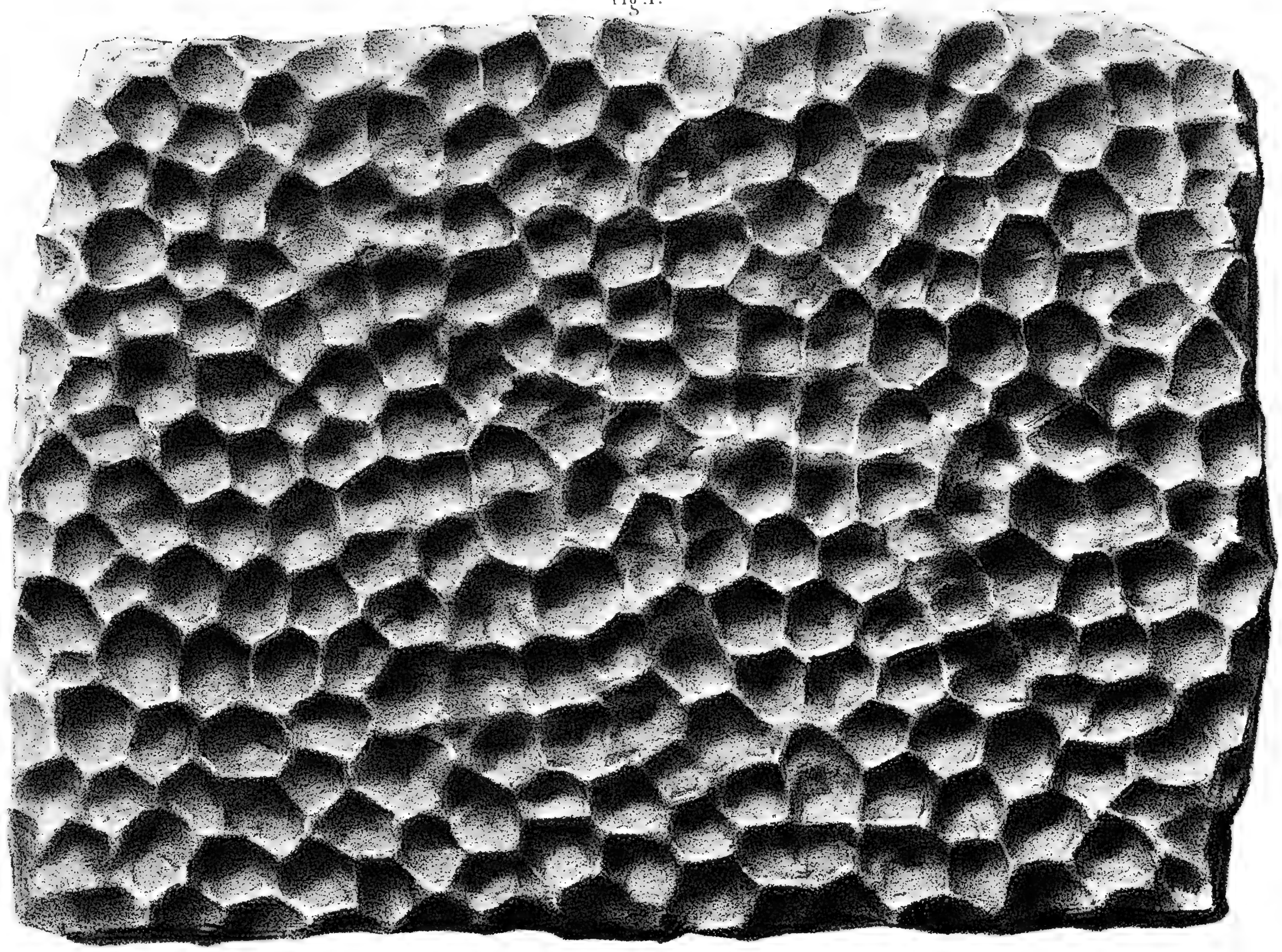
Fig. 7.



2 in. x 3.75 in.

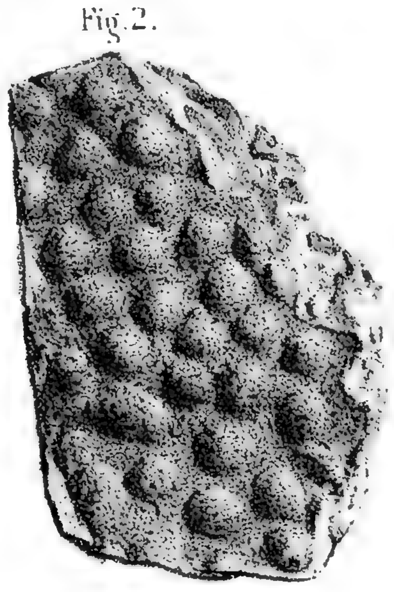
L. H. Bradford & Co's Lith.

Fig. 1.



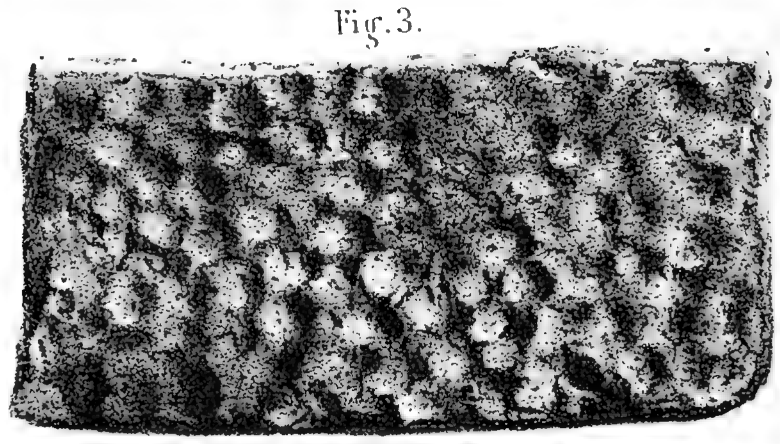
Nests of Batrachoides nidificans
33 in. X 26 in.

Fig. 2.



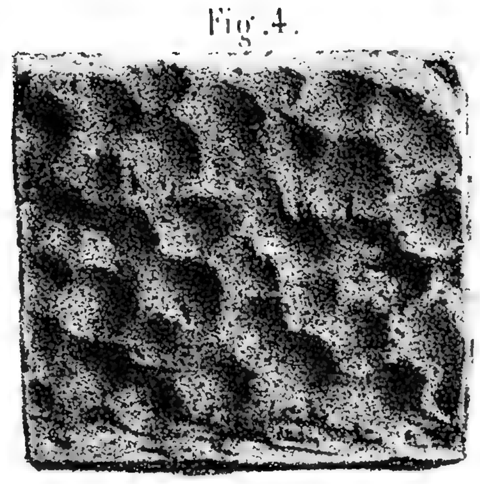
Batrachoides antiquior
10 in. X 2 in.

Fig. 3.



Recent Tadpole Nests.
8 in. X 10 in.

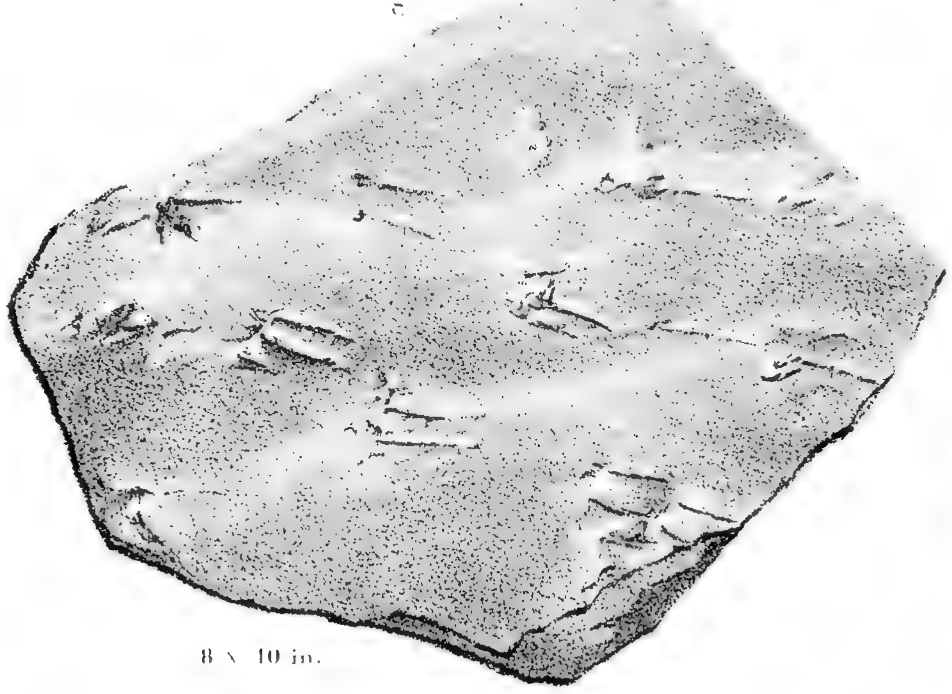
Fig. 4.



Tadpole Nests.
10 in. X 9 in.

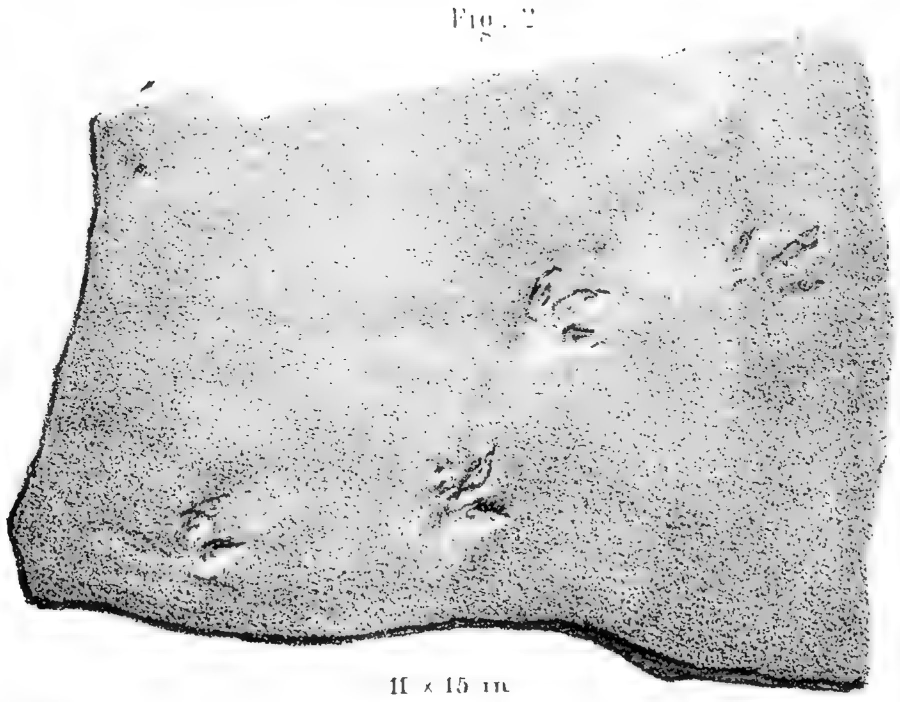
L. H. Bradford & Co. Lith.

Fig. 1.



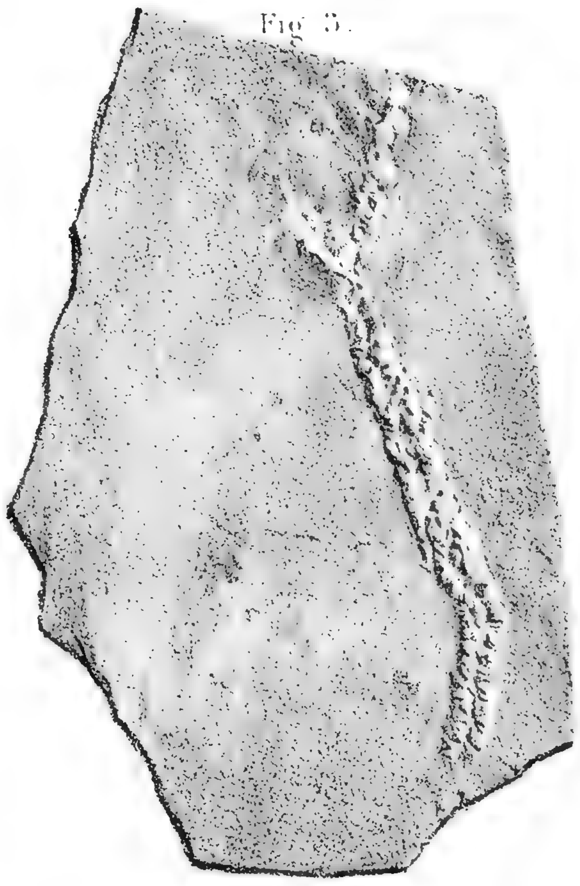
8 x 10 in.

Fig. 2



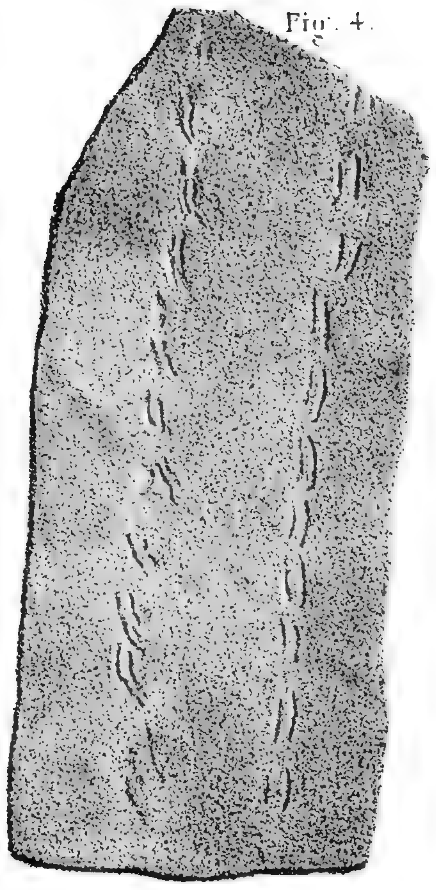
11 x 15 in.

Fig. 3.



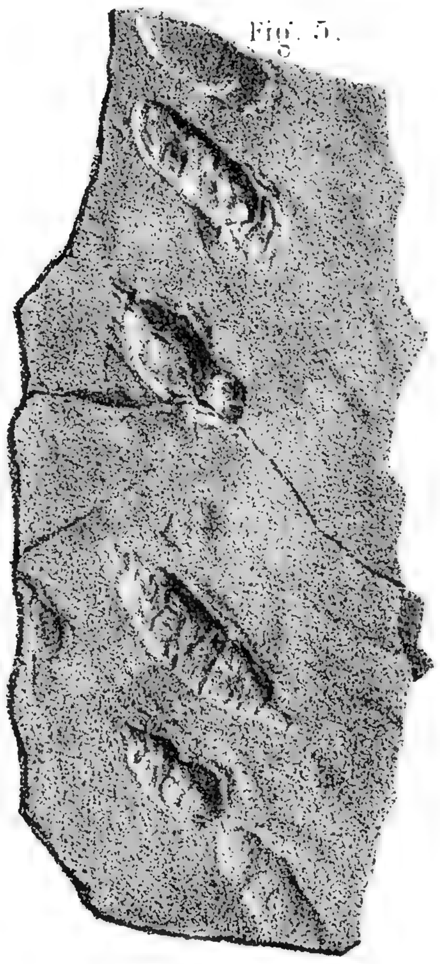
7 x 12 in.

Fig. 4.



4 x 7 in.

Fig. 5.

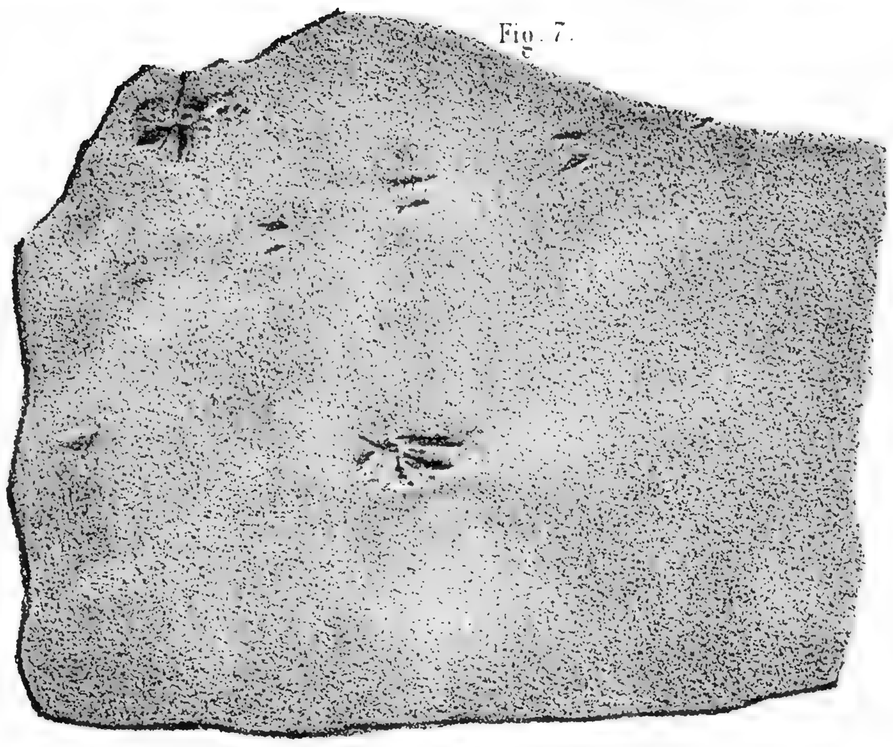


3 x 10 in.

Fig. 6.

7 x 10 in.

Fig. 7.



6 x 8 in.

Bradford & Co's Lith.

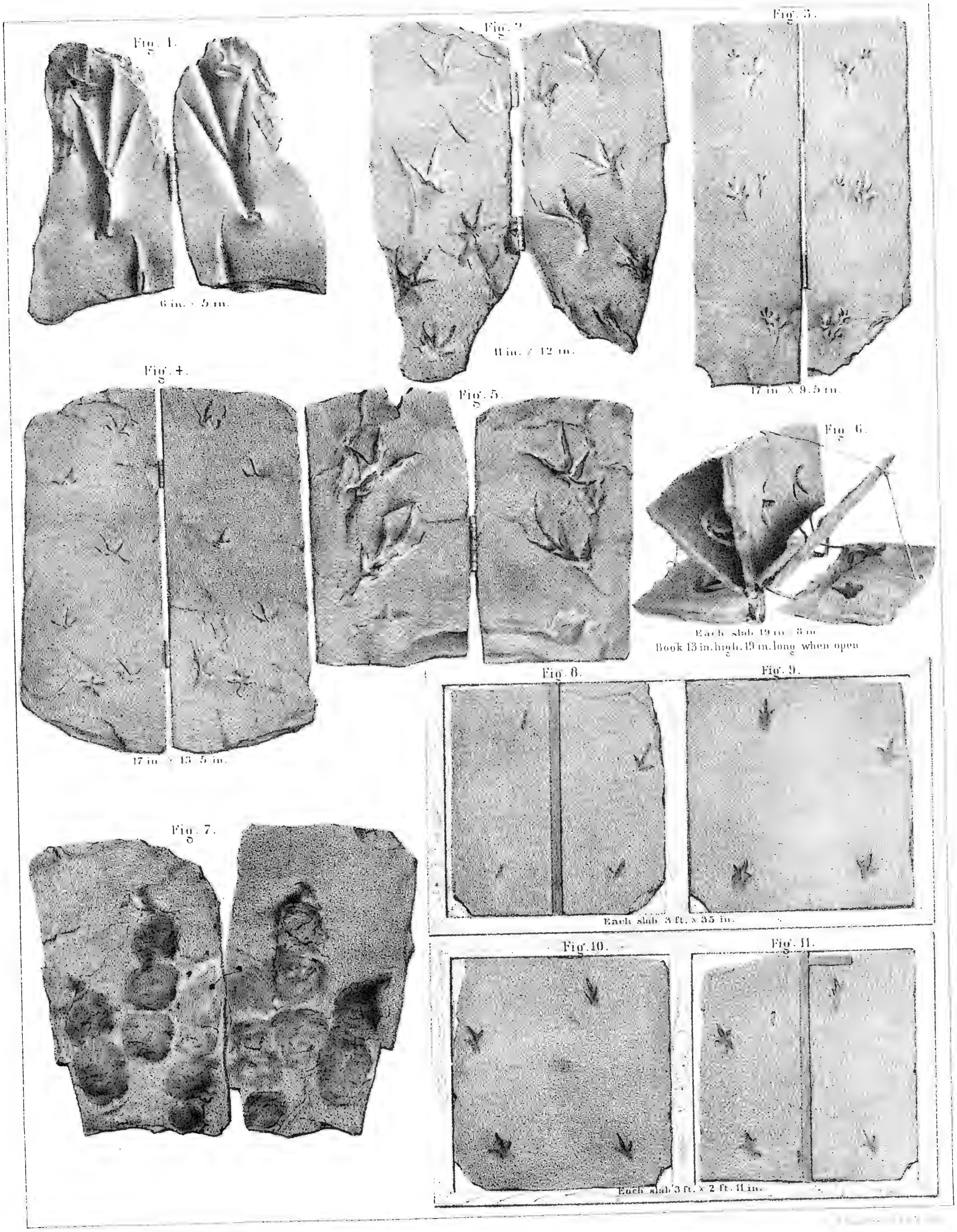
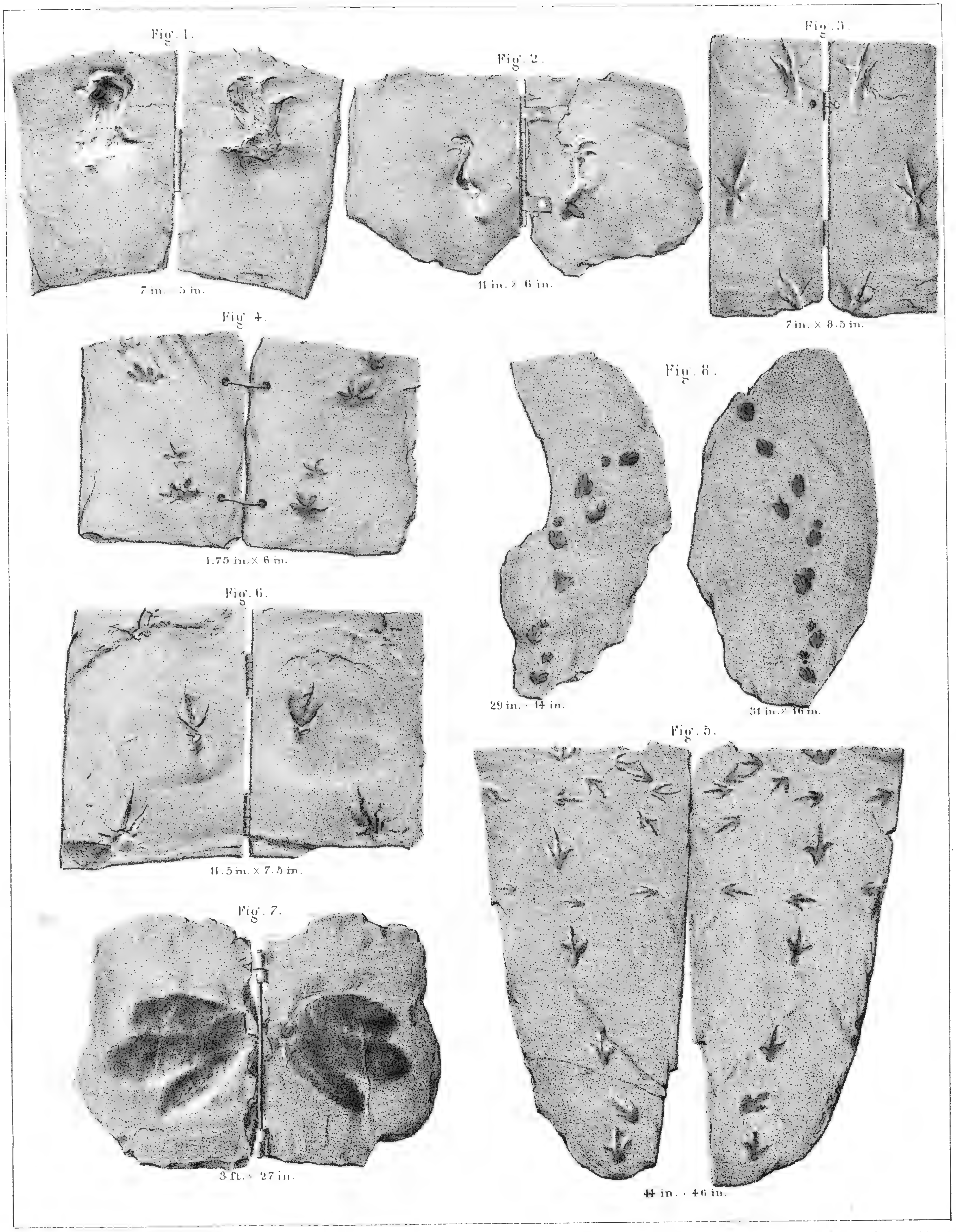
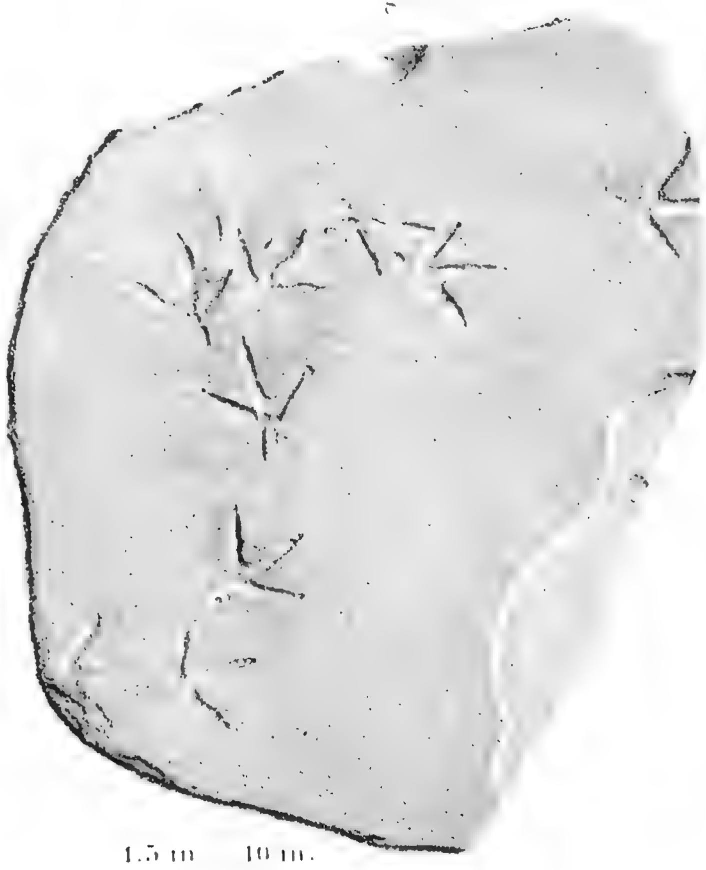


Fig. 1.
6 in. × 5 in.
Fig. 2.
11 in. × 12 in.
Fig. 3.
17 in. × 9.5 in.
Fig. 4.
17 in. × 13.5 in.
Fig. 5.
Fig. 6.
Each slab 19 in. × 8 in.
Book 13 in. high. 19 in. long when open
Fig. 7.
Fig. 8.
Fig. 9.
Each slab 3 ft. × 35 in.
Fig. 10.
Fig. 11.
Each slab 3 ft. × 2 ft. 11 in.



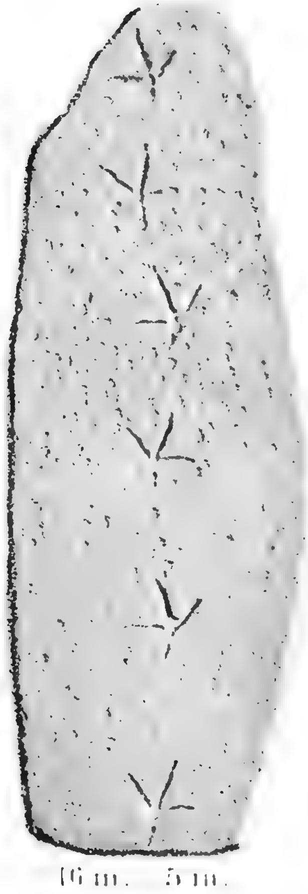
L. H. Bradford & Co's Lith.

Fig. 1.



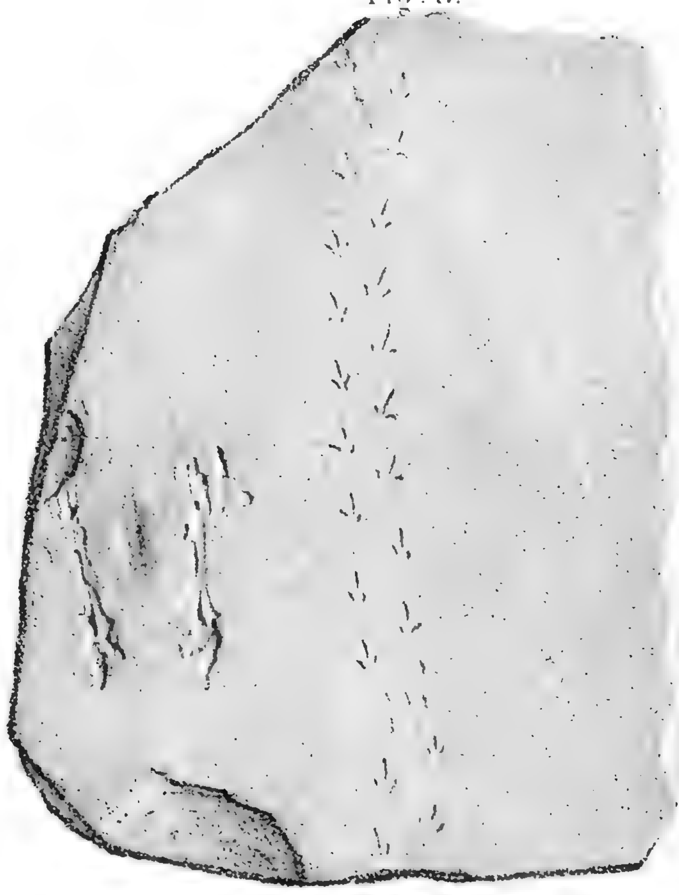
15 in. × 10 in.

Fig. 2



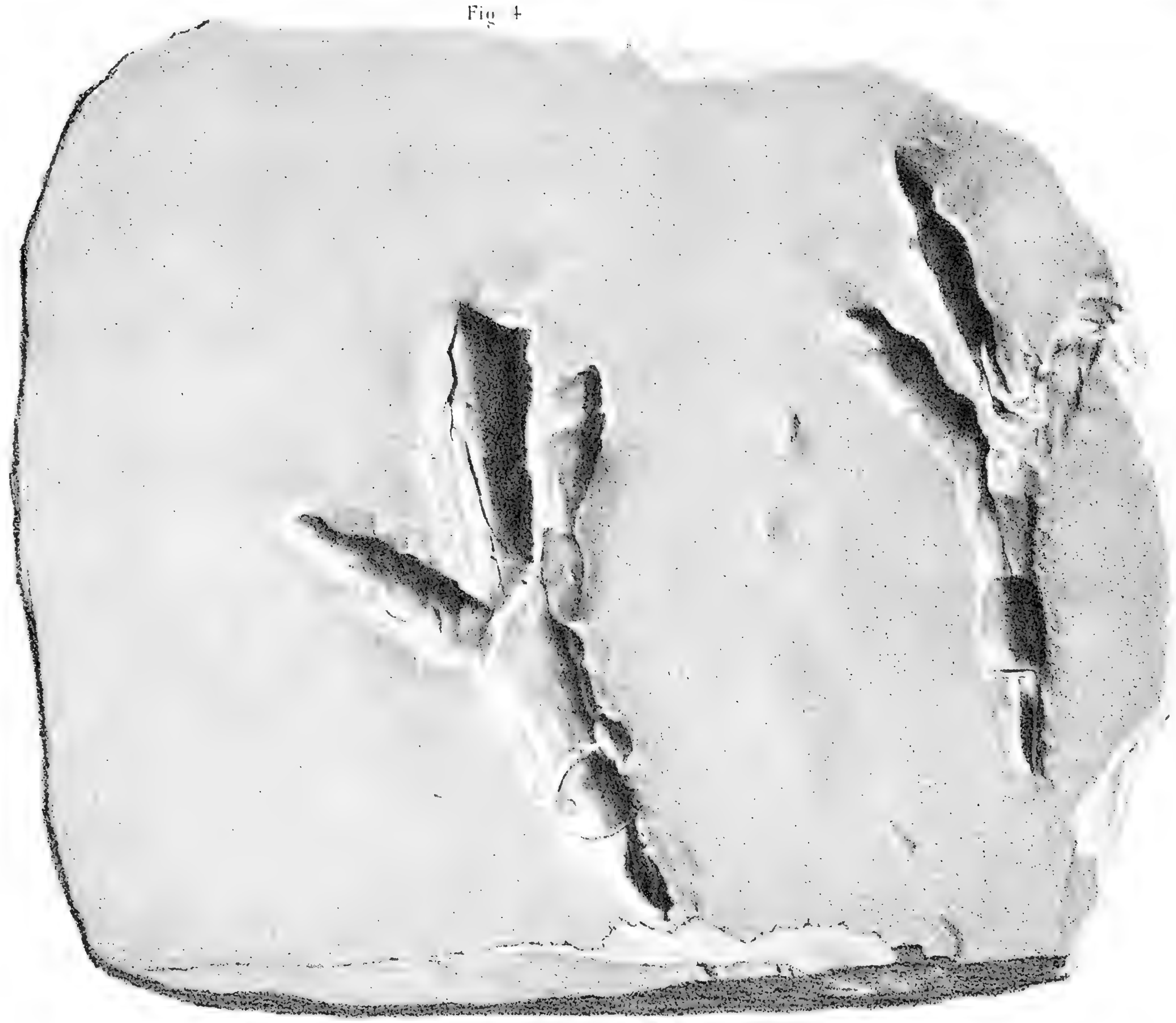
16 in. × 5 in.

Fig. 3.



16 in. × 9 in.

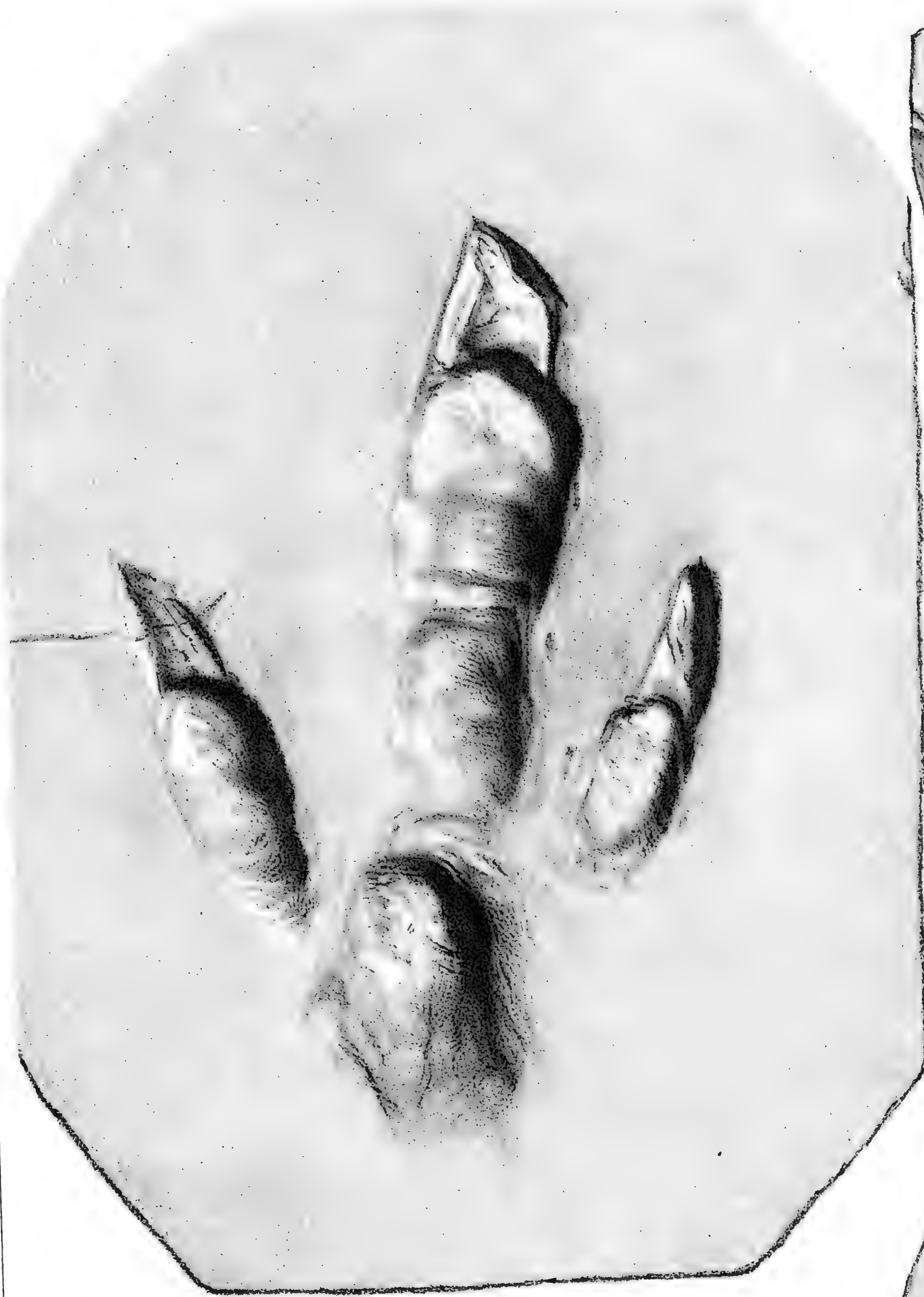
Fig. 4



6 in. × 5 in.

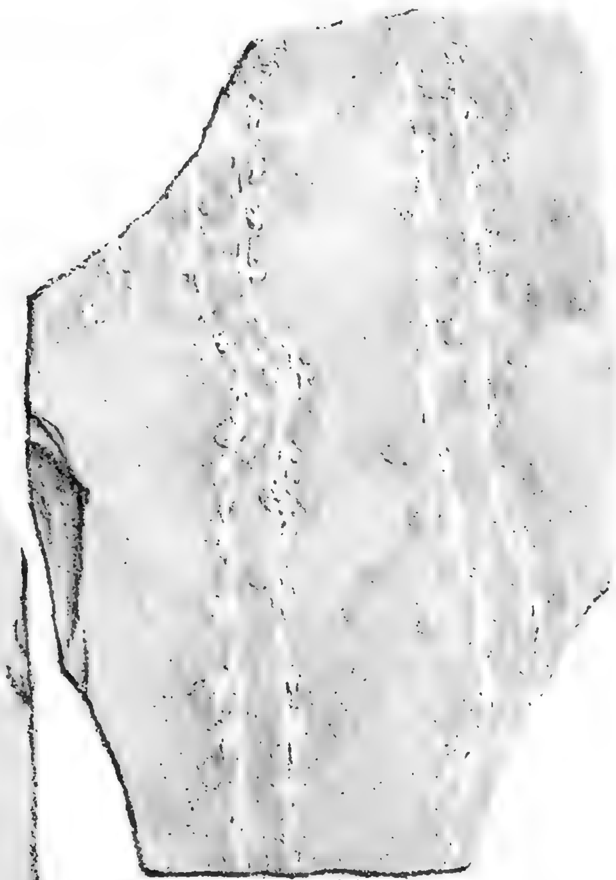
L. H. Bradford & Co.

Fig. 1



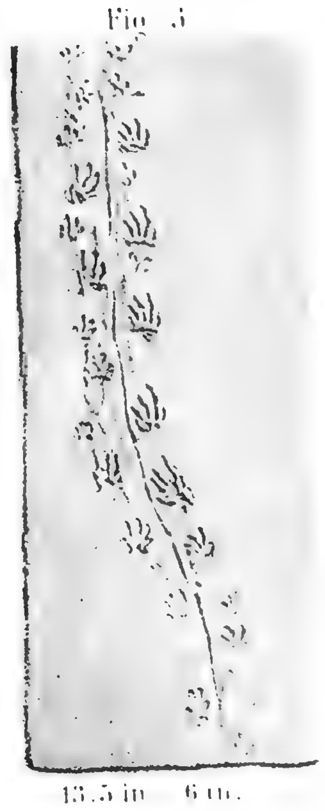
7 in. 5 in.

Fig. 2



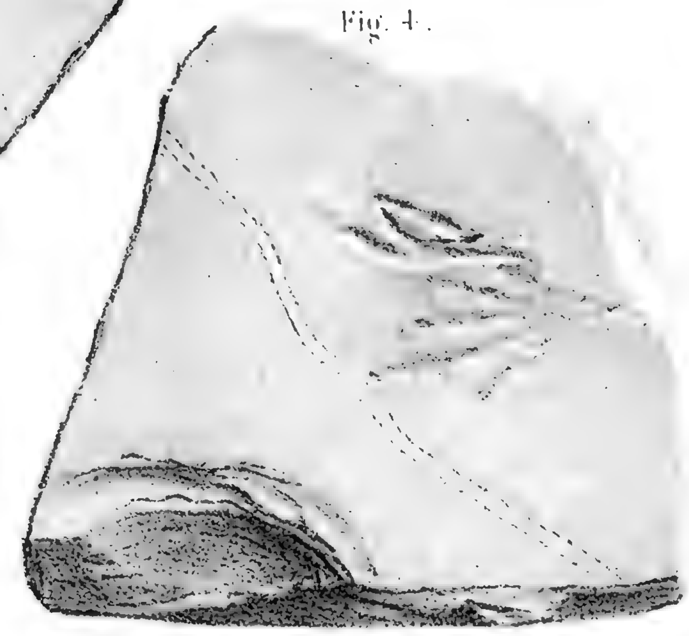
9 in. 6 in.

Fig. 3



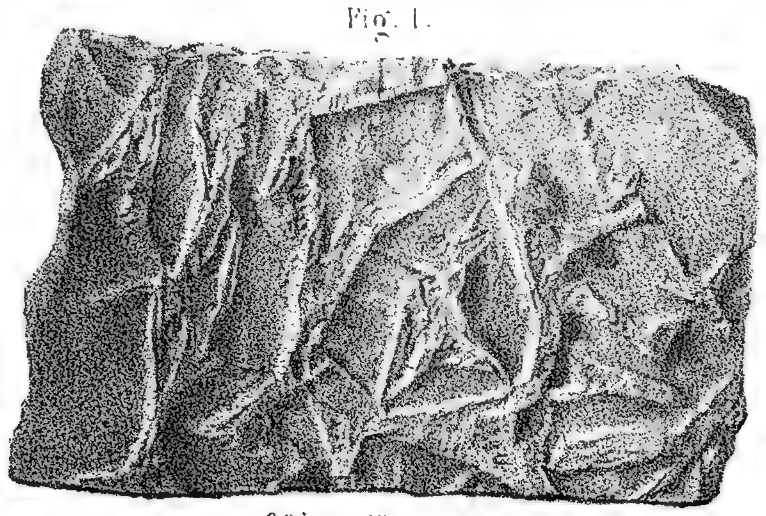
13.5 in. 6 in.

Fig. 4.



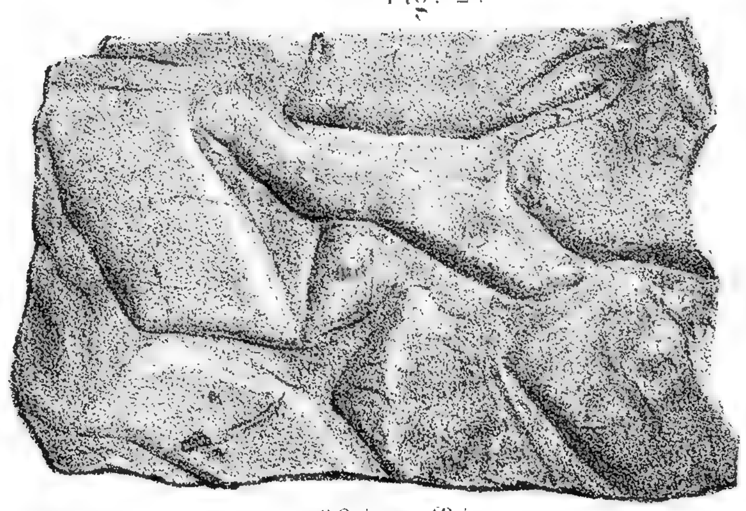
3 in. 2 in.

Fig. 1.



31 in. × 19 in.

Fig. 2.

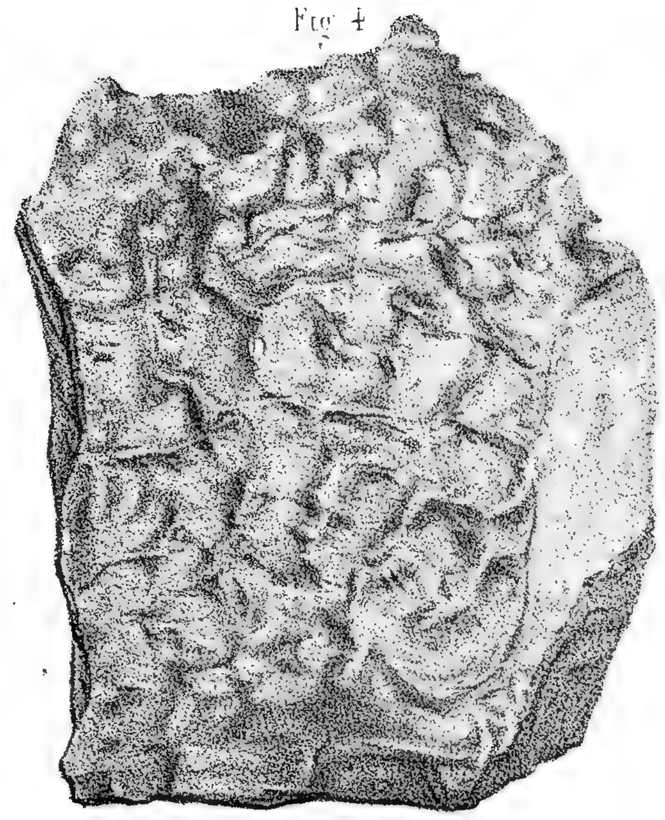


30 in. × 19 in.

Fig. 3.

35 in. × 18 in.

Fig. 4.

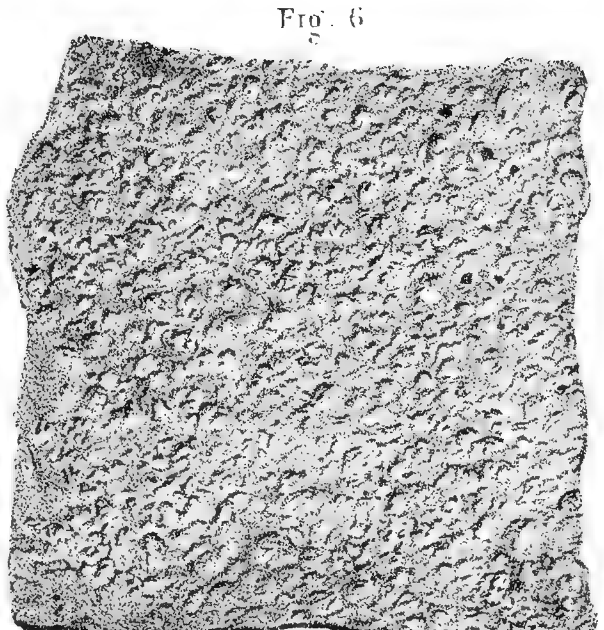


14 in. × 13 in.

Fig. 5.

10 in. × 5.5 in.

Fig. 6.

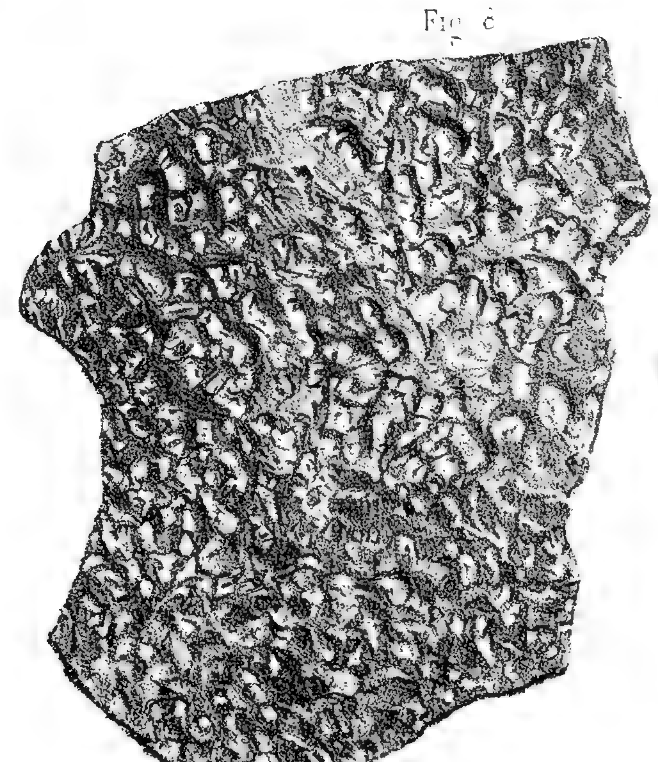


4 in. Sq.

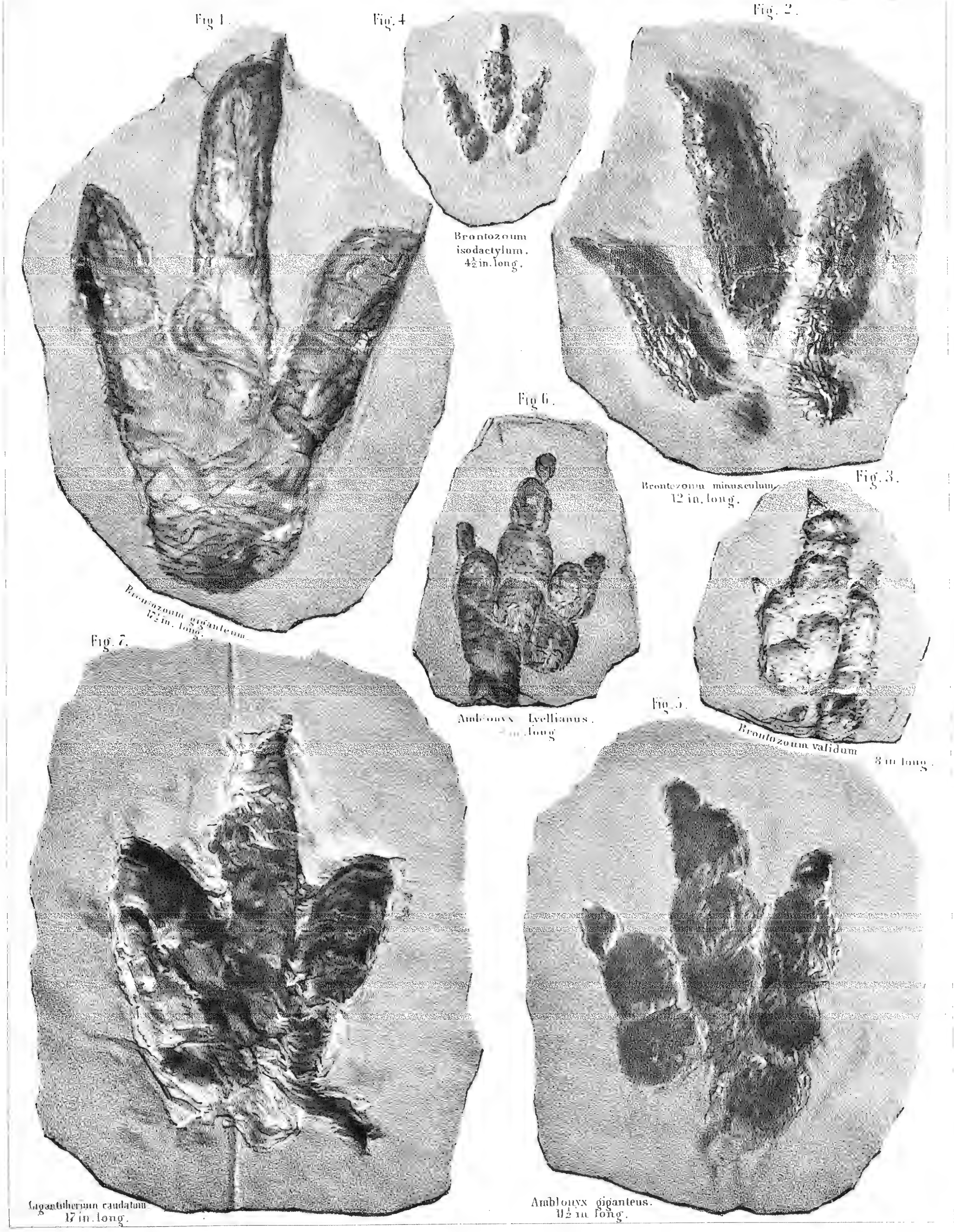
Fig. 7.

9 in. × 5.5 in.

Fig. 8.



7 in. × 6 in.



L.H. Bradford & Co's. Lith.

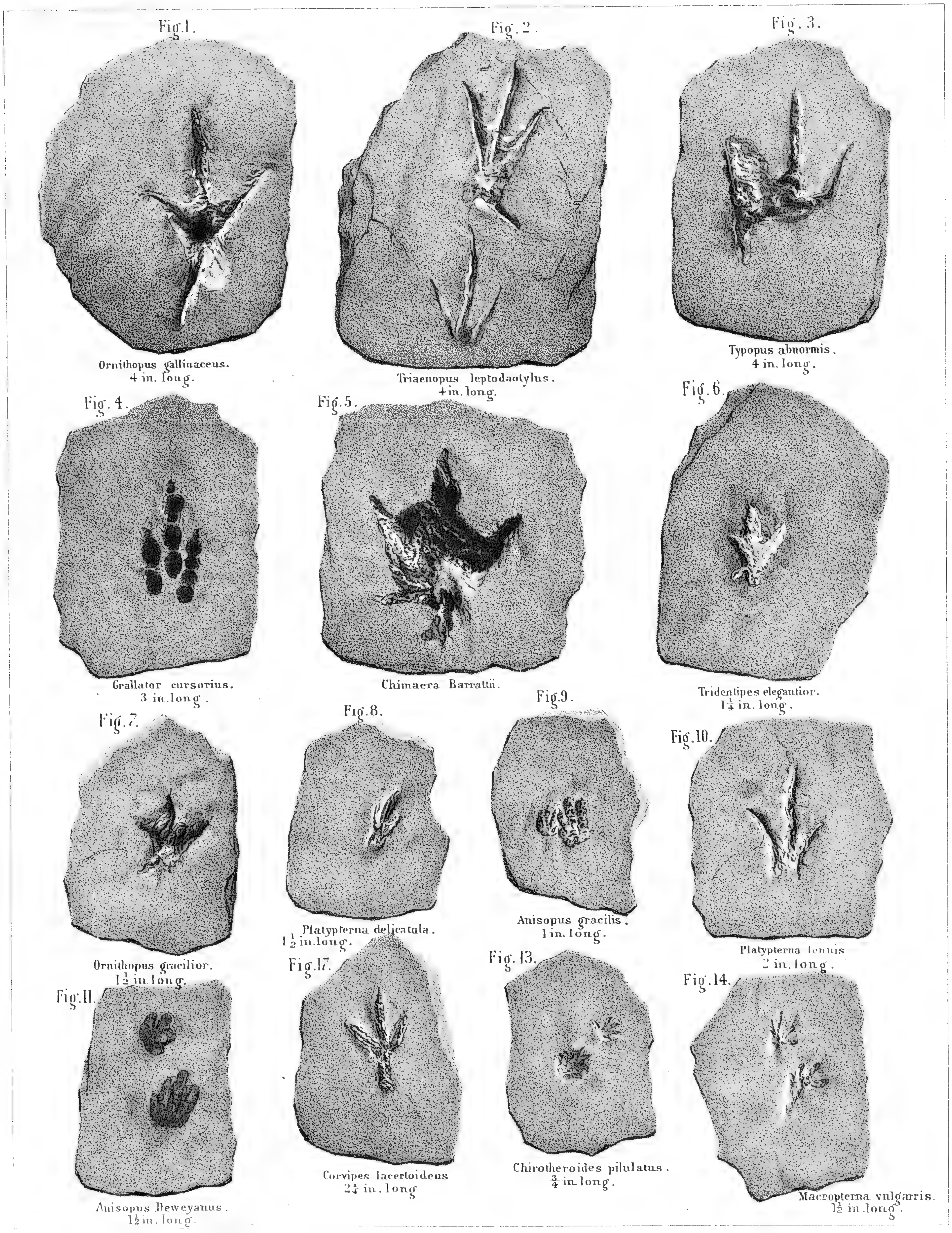


Fig. 1. Ornithopus gallinaceus. 4 in. long.

Fig. 2. Triaenopus leptodactylus. 4 in. long.

Fig. 3. Typopus abnormis. 4 in. long.

Fig. 4. Grallator cursorius. 3 in. long.

Fig. 5. Chimaera Barrattii.

Fig. 6. Tridentipes elegantior. $1\frac{1}{4}$ in. long.

Fig. 7. Ornithopus gracilior. $1\frac{1}{2}$ in. long.

Fig. 8. Platypterna delicatula. $1\frac{1}{2}$ in. long.

Fig. 9. Anisopus gracilis. 1 in. long.

Fig. 10. Platypterna tenuis. 2 in. long.

Fig. 11. Anisopus Deweyanus. $1\frac{1}{2}$ in. long.

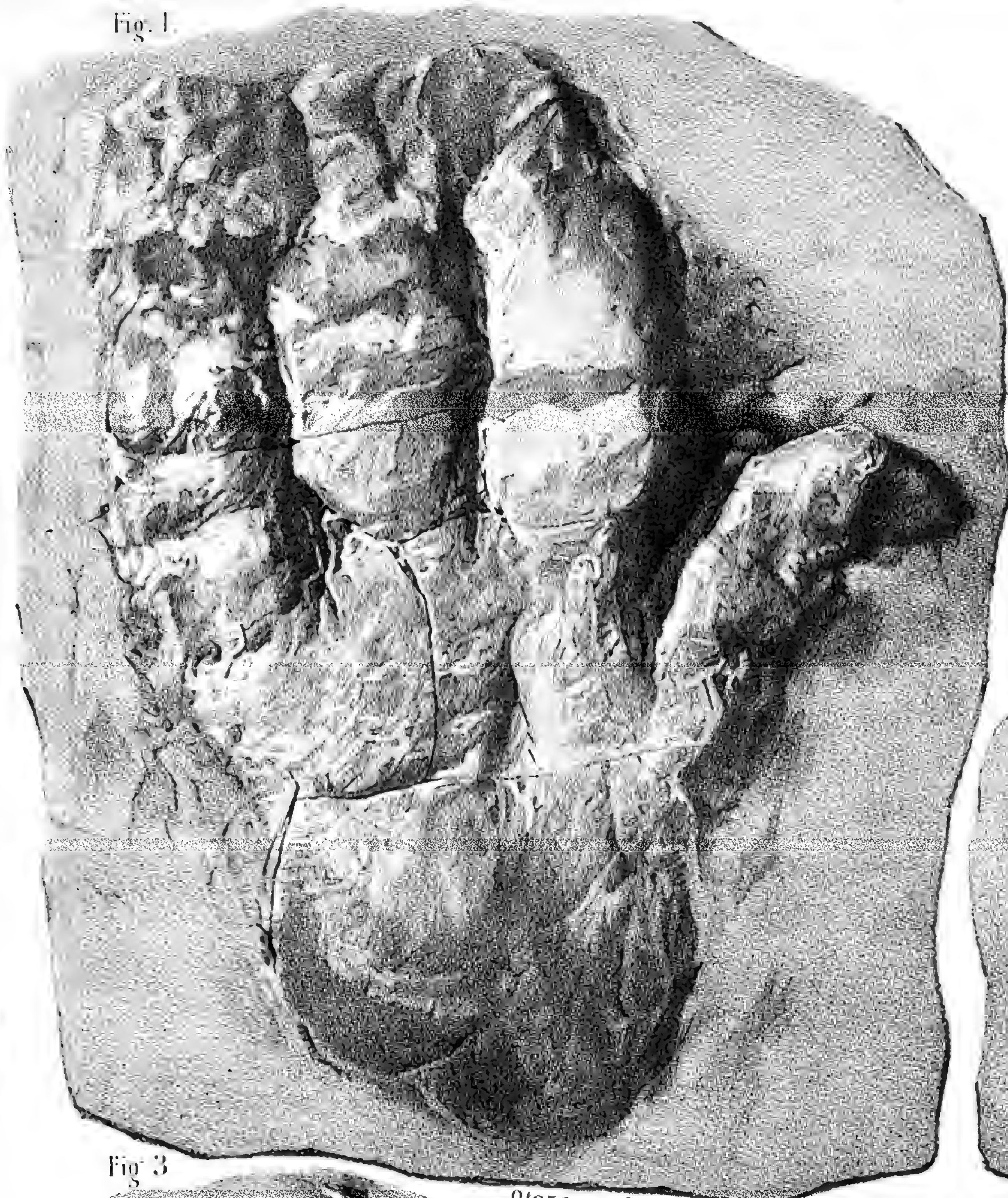
Fig. 12. Corvipes lacertoideus. $2\frac{1}{4}$ in. long.

Fig. 13. Chirotheroides pilulatus. $\frac{3}{4}$ in. long.

Fig. 14. Macropterna vulgarris. $1\frac{1}{2}$ in. long.

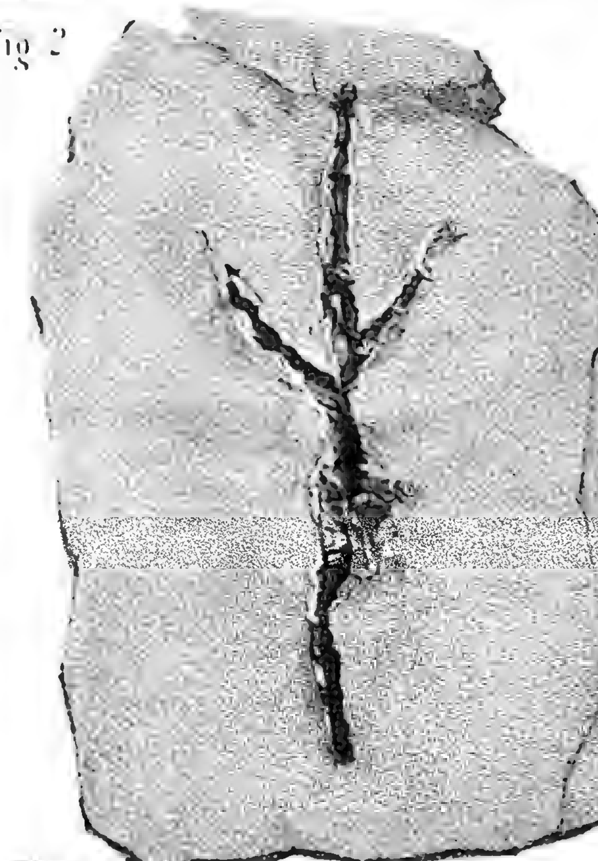
L. H. Bradford & Co. Lith.

Fig. 1.



Otozoum Moodii.
19½ in. long.

Fig. 2.



Plectropterna minitans
9 in. long.

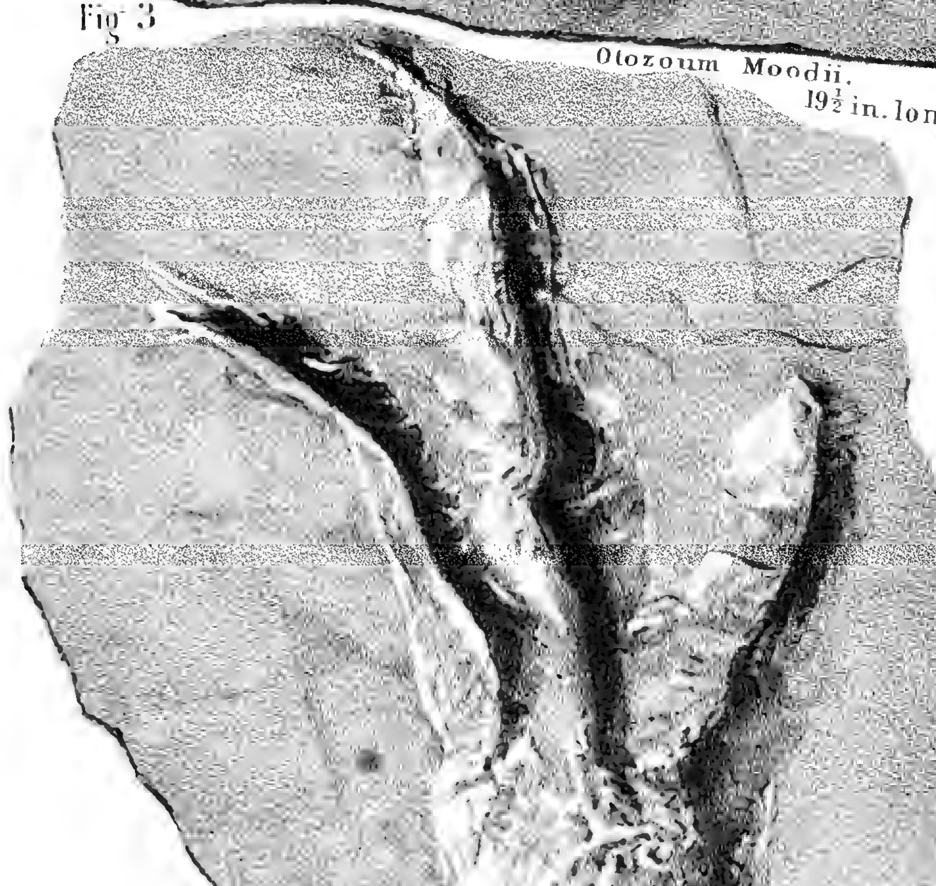
Fig. 4.

Chimaera Barrattii.
7 in. long.

Fig. 5.

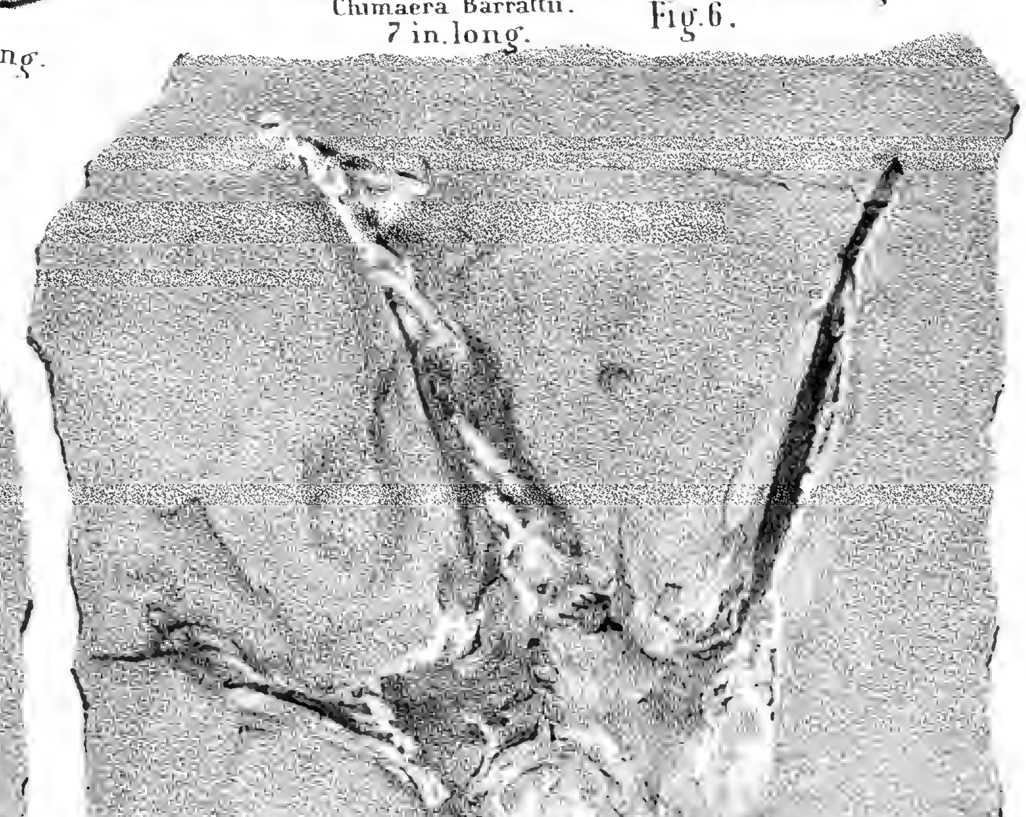
Chimaera ?
5 in. long.

Fig. 3.



Polemarchus gigas.
14½ in. long.

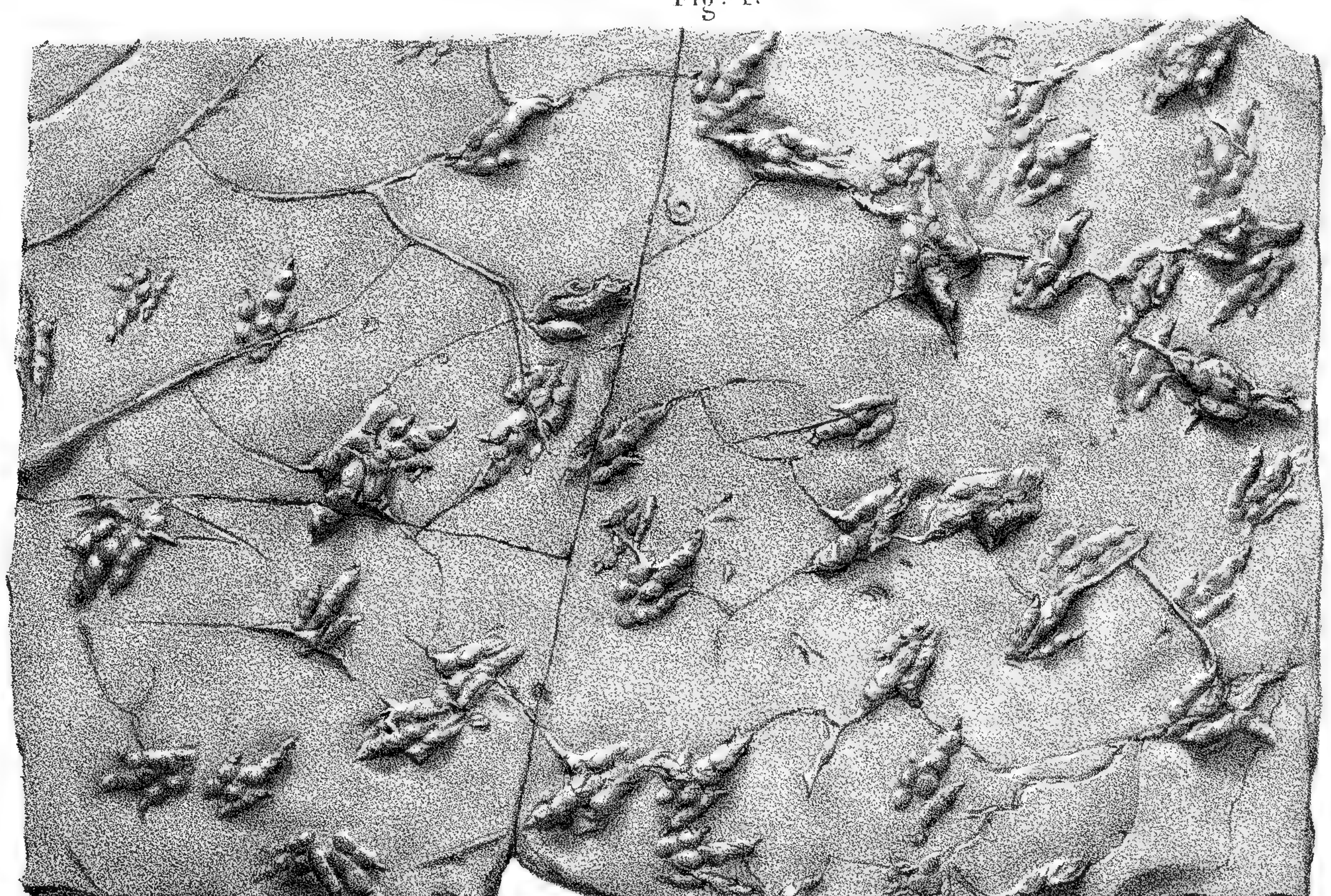
Fig. 6.



Argozoum Redfieldianum.
13 in. long.

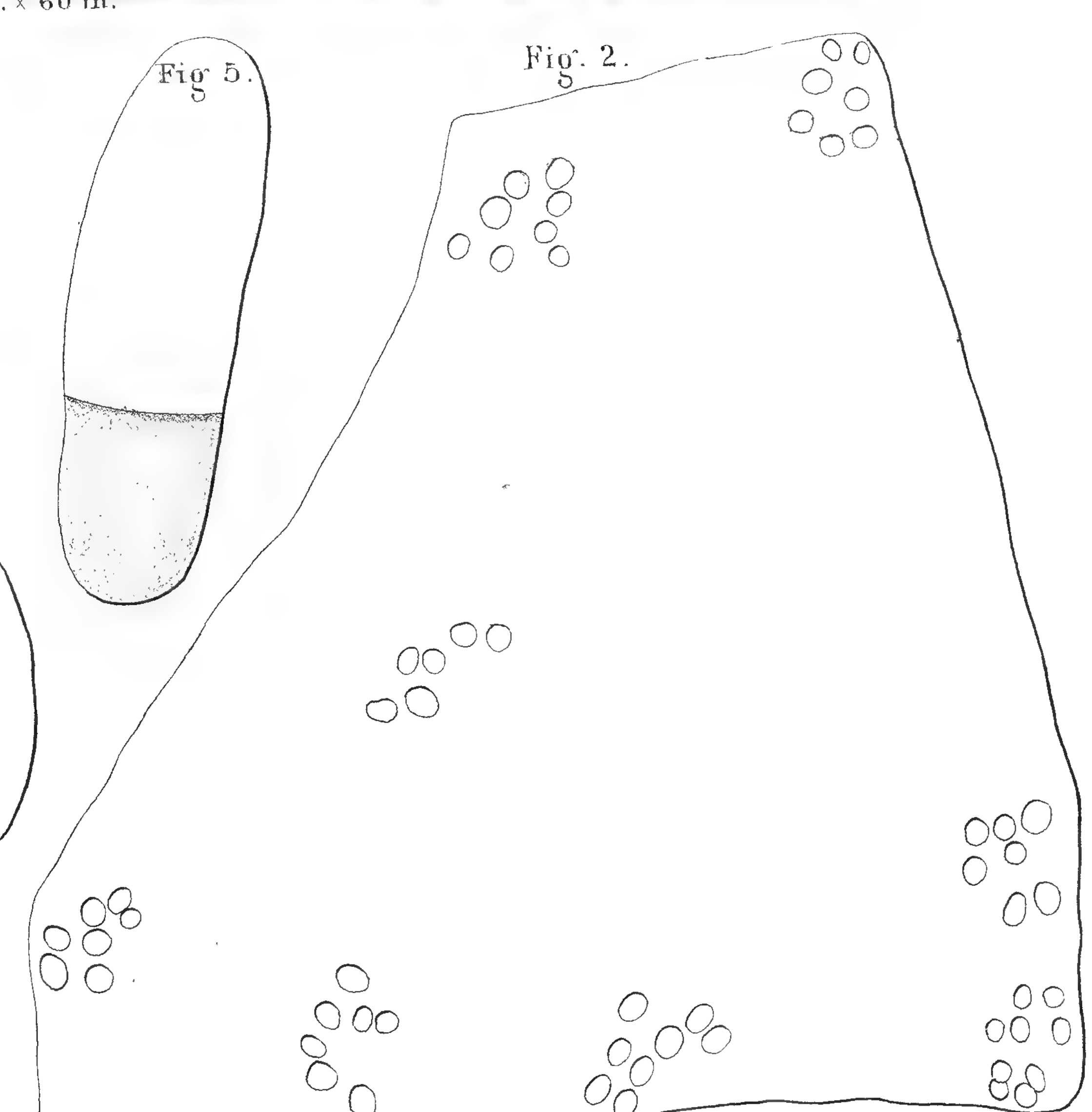
L. H. Bradford & Co. Lith.

Fig. 1.



38 in. × 60 in.

Fig. 2.



Cunichnoides marsupialoideus.
23 in. × 24 in.

Fig. 3.

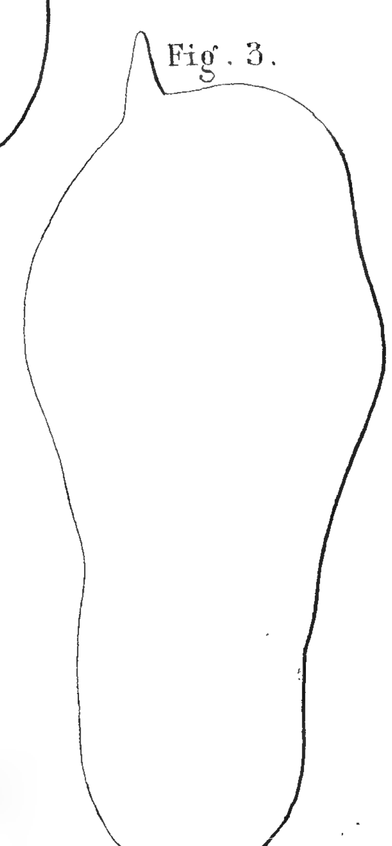


Fig. 4.

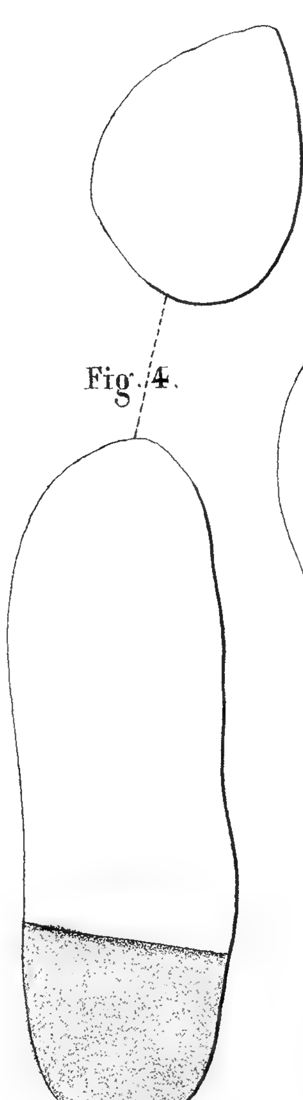


Fig. 5.

Fig. 6.

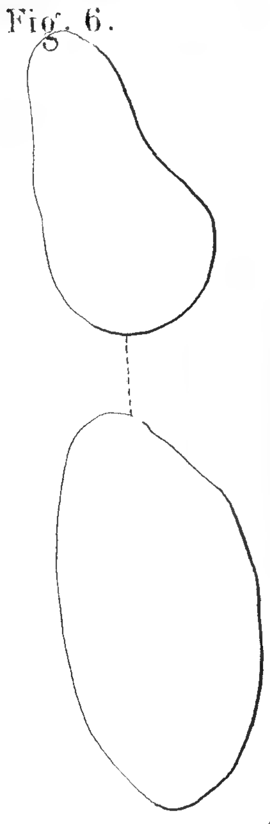
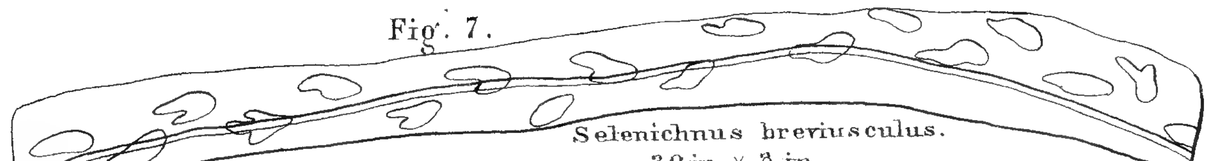
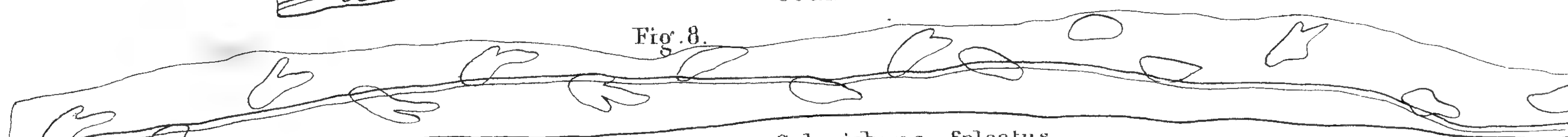


Fig. 7.



Selenichnus breviusculus.
30 in. × 3 in.

Fig. 8.



Selenichnus falcatus.
3 in. × 50 in.

L. H. Bradford & Co's Lith.

SUPPLEMENT

TO THE

ICHNOLOGY OF NEW ENGLAND.

A REPORT

TO THE

GOVERNMENT OF MASSACHUSETTS,

IN

1863.

By EDWARD HITCHCOCK, D. D., LL.D.,

Late Professor of Geology in Amherst College.

BOSTON:

WRIGHT & POTTER, STATE PRINTERS, No. 4 SPRING LANE.

1865.

Commonwealth of Massachusetts.

Executive Department, Boston, January 13th, 1864.

To the Honorable the House of Representatives:

I have the honor to transmit to the General Court, a Supplement by Professor Edward Hitchcock, to his Report on the Ichnology of New England, which was published by the Legislature of 1858. This Supplement was communicated to me by the learned author at the close of the last year, and is accompanied by valuable drawings and photographs illustrating the subject which it treats.

JOHN A. ANDREW.

Commonwealth of Massachusetts.

[Resolves of 1864—Chapter 14.]

RESOLVE IN RELATION TO PROFESSOR HITCHCOCK'S SUPPLEMENTARY REPORT ON THE ICHNOLOGY OF NEW ENGLAND.

Resolved, That one thousand copies of Professor Edward Hitchcock's Supplement to his Report on the Ichnology of New England, with the drawings and photographs connected therewith, be printed at the expense of the Commonwealth, under the direction of the Committee on the Library; that one hundred copies of said Supplementary Report be given to Professor Hitchcock; three copies to the State library, and one copy to each free public library established under the statutes of the Commonwealth; twelve copies to the trustees of the State library, to be used for the purpose of international exchanges; and one copy furnished to each member of the executive and legislative departments of the government for the present political year, and one copy to each town and city in the Commonwealth.—*Approved by the Governor, March* 2, 1864.

JOINT STANDING COMMITTEE OF THE LEGISLATURE ON THE LIBRARY,

For 1864.

Messrs. Otis Cary, of Foxborough,
Lewis J. Dudley, of Northampton,
Thomas L. Chapman, of Longmeadow,
Of the Senate.

Messrs. Charles Beck, of Cambridge,
Joseph Allen, of Northborough,
Abel Wetherbee, of Adams,
Of the House.

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LETTER FROM THE AUTHOR.

To His Excellency John A. Andrew, *Governor of Massachusetts:*

Honored Sir, — Quite unexpectedly I have an opportunity to present to your Excellency a Supplement to the Ichnology of New England, published by the Legislature of 1858. The facts and conclusions have been mostly obtained by me since my confinement in a sick-room, and since the time when I had given over all expectation of any farther researches on this subject. But, as will be explained more fully in the paper, access to new specimens has brought out thirty-seven new species, many of which are very anomalous and instructive, leading to conclusions of great importance in Ichnology, fully confirming the principal conclusions of that Report, and in the opinion of learned friends tending to other inferences of the deepest interest in relation to the animals of Sandstone days that occupied the Connecticut Valley. As the Government of the State, in a very generous and liberal spirit, brought out the full details of the facts known in 1858, it has seemed to me that they would feel desirous of adding those of the sequel also. It will form a pamphlet of the quarto size, of between thirty and forty pages, with twenty plates of the same size, some of the latter, however, doubled, and the principal expense will be in the plates. Yet the whole will not be large, and my fear has been lest the Government might regard even the whole of my paper as almost too small to deserve a formal presentation to their notice. But the intimate connection of the facts and conclusions with my Report of 1858, has determined me to offer the Supplement.

The high reputation, as patrons of science, which the Government of Massachusetts acquired among the savans and scientific journals, by the promptness and style in which they brought out my Ichnology in 1858, (leaving its real merits out of the account,) must be gratifying to every friend of learning in the States. For, as a matter of mere science, probably no other popular government on the globe would do it, under the circumstances. If they should repeat the experiment, even on so small a scale as to bring out in similar style the Supplement, at a time when the public expenses are necessarily very great, it would be an example yet more worthy of imitation, evincing a determination not to allow the cause of learning to suffer, even in the midst of a most disastrous war.

With high respect,

Your obedient servant,

EDWARD HITCHCOCK.

Amherst, Mass., December, 1863.

PREFACE BY THE EDITOR.

The Editor of the following pages deems it important to make a brief statement respecting their preparation. The "Supplement to the Ichnology of New England" was prepared by his late honored father during the last few months of his life, and was accepted for publication by the Legislature of Massachusetts in 1864, shortly after his decease. Expecting a favorable response to his application, he had requested the Editor — his youngest son, formerly Curator of the Cabinets of Natural History belonging to Amherst College — to correct and supervise the publication of his manuscript, to label anew his Ichnological Cabinet according to the revised nomenclature, and to prepare a descriptive catalogue of all the specimens — a work commenced but not completed by himself — to be appended to the Supplement. The Editor was also requested to perfect the list of species as much as possible, either by dropping old names or adding new ones, particularly upon the basis of the modified doctrines distinguishing between the Birds and Reptilian Birds.

The Editor has endeavored faithfully to carry out the wishes of his dying parent. Printed labels, giving the localities of the slabs, as well as the names of the Lithichnozoa, have been attached to every specimen, and a descriptive catalogue is presented as an Appendix in this volume. A few additions have been made to the text of the Supplement in the form of Notes. Only one old name has been changed and two new species added, though others perhaps might have been presented.

It should be stated for the guidance of students of Ichnology, that the originals of a few of the new species of Acanthichnus described in the Supplement could not be found. Whenever new examples of them are discovered, they can be identified by their representations in the plates.

The statement in the Note on page 199 of the Ichnology, that all the species described but one were in the Cabinet, should be corrected. The Cabinet now contains examples of every species of footmark described in the Ichnology and the Supplement, and generally the types of the descriptions.

The Lithographs in this volume were executed by A. Meisel, of Boston, and are faithful copies of the original drawings. The Photographs were executed by J. L. Lovell, of Amherst, who has attained a high degree of efficiency in this department of photography.

The Trustees of Amherst College, in commemoration of the originator and successful expounder of the science of Ichnology, have voted to call the collection of Footmarks the *Hitchcock Ichnological Cabinet;* applying the name *Appleton* to the whole building, which contains the *Adams Cabinet* in the second, and the *Hitchcock Cabinet* in the first story.

C. H. HITCHCOCK.

No. 37 Park Row, New York,
June 20th, 1865.

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SUPPLEMENT

TO THE

ICHNOLOGY OF NEW ENGLAND.

FOR more than two years past, I have spent a considerable time in making out a descriptive Catalogue of the large collection of Fossil Footmarks in Amherst College. Although I had described the most prominent features of the specimens in the "Ichnology" published by the Government of the State, yet when I came carefully to study them, I found several new species, and reasons for giving up some of the old ones; also, some disclosures that throw light on the fundamental principles of Ichnology.

A still more fruitful source of new information has been the purchase from Mr. ROSWELL FIELD, of a large collection of footmarks made by him at Turner's Falls, some of which exhibit great perfection. A new room has been fitted up for them in the College. The whole number of individual tracks previously in the Cabinet was over twelve thousand. The new purchase will add several thousand more, bringing up the whole number above twenty thousand: several thousand of which, however, are the tracks of insects.

I began this Cabinet twenty-five years ago, and have received great assistance from the benefactions of generous friends of science. Three rooms are now devoted to it, the largest of which is one hundred feet by thirty: the second, a side room, is twenty-seven feet by eleven, and the third, also a side room, twenty-two feet by eleven: all of which are as full as desirable. Large as the collections may seem, I am satisfied of the great importance of increasing them to almost any extent, in order to furnish materials for those who are investigating the subject of footmarks, and to prevent their making serious blunders. The late addition has already brought out disclosures amply compensating the thousand dollars paid for it by liberal friends of science.

Species of the Ichnology not reliable.

I am satisfied that the following six species, most of which are given as doubtful in the Ichnology, ought not to be retained. It is hardly necessary to offer here the particular reasons which led to their rejection.

Brontozoum isodactylum.
Platypterna gracillima.
Batrachoides antiquior.
Ptilichnus typographus.
Ptilichnus pectinatus.
Grammepus uniordinatus.

Doubtful Species.

I suspect that the tracks of the following species may be imperfect developments of peculiar forms of other species; such forms as sometimes occur on layers of rock above or below that on which the animals trod. As to the two first-named species, however, my doubts result from an apprehension that the rounded form of the claw on the track, which gives the character of the genus, may originate from other causes than the rounded or winged character of the claw itself.

Amblonyx giganteus.
Amblonyx Lyellianus.
Argozoum Redfieldianum.
Platypterna Deaniana.
Tridentipes uncus.

New Species.

Even if all the eleven preceding species should be rejected, I shall be obliged to propose treble the number of new ones. I rather regret this than rejoice at it. For I would pefer to see the number of species in the Ichnology reduced rather than increased. Yet if I follow the principles laid down in that work, whose correctness I have not yet seen reason to doubt, I must add the following species, thirty-seven in number.

1. Anomœpus intermedius. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{16}{3}$, $\frac{19}{14}$, $\frac{21}{3}$, $\frac{26}{10}$, $\frac{32}{57}$, $\frac{48}{1}$, $\frac{50}{1}$, $\frac{50}{2}$, $\frac{51}{1}$, $\frac{51}{2}$, $\frac{51}{5}$, $\frac{51}{9}$, $\frac{51}{14}$, $\frac{52}{4}$, $\frac{53}{5}$, $\frac{53}{10}$, $\frac{54}{13}$, $\frac{55}{112}$.]

This is the most remarkable and instructive of all the genera of the Lithichnozoa. I propose three new species and though I have been studying these tracks for twenty years, yet, the descriptions which I give below, contain several new and important characters not hitherto brought out.

Hind Foot.—Tridactylous, the three toes articulated to a single tarso-metatarsal bone several inches long, which the animal had the power of bringing down to the ground so as to make an impression. The toes are pachydactylous with two phalanges in the inner toe (exclusive of the ungual,) three in the middle, and four in the outer toe; claw rather broad and rounded, that process making an impression nearly behind the outer toe, as in most tridactyle living birds. Indeed the whole foot as far as the tarsal joint, exactly resembles that of a tridactylous bird. Tail-trace narrow and continuous. Average divarication of the lateral toes, 70°. Length of the inner toe, 2.3 inches; of the middle toe, 3 inches; of the outer toe, 2 inches; of the foot, 4 inches; of the step 5 to eight inches; of the heel, nearly 3 inches. Average width of the phalanges, 0.7 inch. Papillæ of the foot and the heel, round of the size of a mustard seed. Width of the trackway, 6 to 7 inches. Phalanges of the inner toe exclusive of the ungual phalanx, two; of the middle toe, three; of the outer toe, four.

Fore Foot.—Pachydactylous, pentedactylous, unguiculate, digitigrade; the track showing phalangeal impressions from 2 to 4; the third toe from the inside showing the largest number. Papillæ, round, small. Perhaps the fifth toe, which seems to be isolated from the rest on the track, is only the end of the heel. Foot digitigrade, marsupialoid. Length of the longest or third toe, 1.5 inches; of the foot 2.25 inches.

The usual form which the tracks of the hind and fore feet of this species present is given on Plate I., fig. 1. The heel of the hind foot is omitted, as it is in most cases upon the rocks. But the entire tracks of both feet are shown on Plate XV., fig. 1, whose description will show its peculiar and various modes of progression.

This species differs from A. minor in the greater divarication of the lateral toes, the stouter proportions of the whole foot; the less length of the tarso-metatarsal bone, the foot and the step. It is the most common species of the genus, and its ordinary track so greatly resembles that of birds, that it is no wonder we have all regarded its tracks as those of birds, especially the species described in the Ichnology as Brontozoum isodactylum.

A remarkably fine specimen lately obtained, has shown our error, and brought out the peculiarities of structure and progression in the most satisfactory manner. Plate XV., fig. 1, is a true copy of this slab. The specimen shows fifty tracks, probably all of them of Anomœpus, and I am inclined to think all except four are A. intermedius. These four are probably A. gracillimus. The impressions are unusually perfect, showing in most of them more or less of the phalangeal

impressions, and on sixteen of them the papillose imprint of the skin. The tracks form five rows. The first has in it sixteen tracks, and extends from the extreme left hand extremity to the extreme right of the slab, but not in a strait course. A second row of eight tracks commences at the right hand extremity, a little below the middle, and runs near the lower edge, terminating near the middle of the slab, or rather running off the slab. A third row of ten tracks commences near the upper right hand corner, and passes obliquely downward across the slab, leaving it at the same place with the second. After advancing three steps, the animal that made the third row seems to have brought up both his feet abreast of each other, and to have made a leap of six inches, where his tracks are abreast; after which he moved forward as usual, by alternate steps. In all these three rows, and we may say the same of the four small tracks that cross the other rows, a practised observer would see nothing leading him to suspect that the whole thirty-eight were not made by thick-toed tridactyle birds; for even the phalangeal impressions agree in number with those of living birds, and to birds they have generally been referred. But the fourth row of twelve tracks near the upper left hand side makes a different revelation. The first five show the same tridactyle imprints, but at the sixth step the animal brought down two stout heels, three inches long upon his hind feet, and two small five-toed tracks just ahead of the hind ones, after which it went forward as before, using only the toes of the hind feet, though it brings down one of its fore feet, but not its heel at the first step.

Several important conclusions flow at once from the facts. The first is, that this animal was a quadruped with unequal feet. The second is, that it here stopped to rest on all fours, sitting apparently like a frog, and bringing down its heel as far as the tarsal joint. The third is, that commonly in walking it used only the toes of its hind feet, being decidedly digitigrade. The tracks reveal, I think, the same fact in respect to several other species of those ancient animals, ex. gr. the Otozoum. Fourthly, the animal sometimes moved by leaps.

As confirmatory of these conclusions, it ought to be added that this animal had a tail; for just before it sat down on all fours, we find a distinct tail-trace on the stone, and a less perfect one near the right extremity of the longest row, which would not have been noticed, had not the revelations made by the first, awakened careful scrutiny.

Another fact ought to be noticed, although to me inexplicable. I never yet noticed a case where the animal brought to the ground the heel of its hind foot and the fore foot, without placing those on one side of the body in advance of the other, yet scarcely enough in advance to be the result of taking a step. What object could have been subserved by this peculiarity I cannot conceive; but it leads to the

suspicion that we have not yet discovered all the anomalous modes of locomotion possessed by this singular race of animals.

Other specimens in the Cabinet exhibit essentially the same facts as the slab just described, and are so stated in my Ichnology; but none of them bring out the facts so clearly as this specimen. It is certainly an invaluable relic, and had Mr. Field, who dug it out, been aware of its importance when uncovering it, he would have tried hard to preserve a broader surface to show the prolongation of the row of tracks. But he deserves much credit for preserving so large a surface.

2. Anomœpus curvatus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{5}{8}$, $\frac{10}{6}$, $\frac{14}{5}$, $\frac{23}{12}$, $\frac{44}{2}$, $\frac{51}{3}$, $\frac{52}{5}$, $\frac{52}{10}$, $\frac{52}{13}$, $\frac{52}{14}$, $\frac{52}{16}$, $\frac{53}{5}$, $\frac{53}{7}$, $\frac{54}{13}$, $\frac{55}{35}$.]

Hind Foot.—Tridactylous, pachydactylous, tuberculate, digitigrade, ornithoid. Divarication of the lateral toes, 55°. Length of the inner, middle and outer toes, successively, 2, 3, 2.1 inches, exclusive of the heel bone in the outer toe; length of that bone, 0.7; of the foot, 3.8 inches; of the step, 6 to 7 inches. Width of the trackway, 5 to 6 inches. Toes on the track, especially the middle toe, turned inward several degrees, and somewhat curved. Average width of the phalanges, 0.5 inch. Phalanges on the inner, middle and outer toes, exclusive of the ungual and the heel bone, 2, 3, 4.

Fore Foot.—Not yet found on any specimen, but the close resemblance of the hind foot to that of the A. intermedius, makes it almost certain that this is an Anomœpus. It differs from the A. intermedius in being more slender throughout, and the inward curvature of the toes, and especially in the less divarication of the outer toes. Possibly, however, it may turn out to be only a variety of A. intermedius.

Plate I., fig. 2, is an exact outline of what I call the hind foot of this species, copied from one of the most perfect and beautiful specimens in the Cabinet, and shown in Plate XV., fig. 2. The great value of this specimen consists in the distinctness with which it exhibits the phalangeal impressions, showing especially that there are four in the outer toe, besides the heel bone. It settles that point beyond controversy, and I find that several other specimens of Anomœpus show the same thing; so indistinctly, however, that we have overlooked it. But more of this in another place.

3. Anomœpus minimus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{28}{1}$, $\frac{34}{19}$, $\frac{37}{25}$, $\frac{50}{1}$, $\frac{52}{4}$, $\frac{52}{5}$, $\frac{55}{21}$, $\frac{55}{112}$.]

Hind Foot.—Tridactylous, pachydactylous, tuberculate, digitigrade, ornithoid. Divarication of the lateral toes, 60° to 70°. Length of the toes, reckoning outward,

1.3, 1.5, and 2 inches; of the heel bone 0.4 inch; of the foot 2.3 inches; of the step, 2.6 inches. Width of the trackway, 3 inches.

Fore Foot.—Pentedactylous, unguiculate, digitigrade, marsupialoid. Middle toe longest, one inch, with four tubercular expansions and a claw. Next outer toe has three phalanges and a claw, and the outer one two and a claw. The inner toe but one has two phalanges and a claw. The innermost two, but no claw is on the specimen. Fore feet placed just forward of the hind feet and a little inside, nearly abreast, as are also the hind feet, like the other species of Anomœpus.

This species is shown of the natural size on Plate II., fig. 2. Fig. 1, shows the most perfect outline of the fore foot yet discovered.*

4. Anisopus gracilior. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{32}{20}$, $\frac{32}{60}$, $\frac{33}{55}$, $\frac{45}{5}$, $\frac{45}{6}$, $\frac{46}{1}$, $\frac{46}{2}$, $\frac{46}{3}$.]

The chief apparent differences between this species and the A. gracilis of the Ichnology, is its smaller size and shorter stride, but more especially the greater relative width of its trackway. The hind feet are tetradactylous, the fore feet pentedactylous, corresponding in this respect to the Loricoid or crocodilian reptiles. Length of the hind foot, 0.6 inch; and of the fore foot, 0.4 inch; of the step, with the alternate feet, 1.8 inches; of the feet on the same side, 2.5 inches. Width of the trackway, 2 inches. Toes strait; axis of the hind foot divergent, often 20° or 30° from the line of direction.

The short step and the wide trackway of this species show, without doubt, an animal with a broader body and shorter legs than the A. gracilis. The outline of the hind and fore feet is given on Plate I., fig. 3.

* Anomœpus gracillimus.

[In the Cabinet, Nos. $\frac{16}{10}$, $\frac{16}{15}$, $\frac{19}{3}$, $\frac{19}{4}$, $\frac{19}{5}$, $\frac{19}{12}$, $\frac{20}{7}$, $\frac{21}{3}$, $\frac{28}{1}$, $\frac{31}{6}$, $\frac{32}{1}$, $\frac{32}{45}$, $\frac{37}{18}$, $\frac{41}{18}$, $\frac{41}{22}$, $\frac{41}{34}$, $\frac{48}{1}$, $\frac{50}{1}$, $\frac{50}{2}$, $\frac{50}{3}$, $\frac{51}{3}$.]

An examination of all the specimens referred to Brontozoum gracillimum in the Ichnology, has satisfied me that the animal was an Anomœpus, and I venture to make the change in this place. The necessity of the change was brought to my father's notice after it was too late for him to visit the Cabinet; but from his recollection of the peculiar impressions of the animal, he acquiesced in the suggestion. The characteristics of the track calling for the change are these: First, the short stride of the animal; second, the thick, Anomœpus type of the foot, and third, the occasional presence of a long heel upon the hind foot, as in Nos. $\frac{50}{1}$, $\frac{50}{2}$. None of the front feet have yet been discovered.

One might at first glance, refer this ichnite to A. minimus. It differs from it chiefly by the much less divarication of the toes. It will be unnecessary to repeat the description of the species, as it is given mostly in the Ichnology. The chief addition would be the presence of the long heel. It is a somewhat common species in the Cabinet, as evidenced by the list of numbers.—*C. H. H.*

5. Brontozoum divaricatum. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{1}{3}$, $\frac{5}{3}$, $\frac{6}{1}$, $\frac{9}{11}$, $\frac{14}{4}$, $\frac{16}{13}$, $\frac{17}{1}$, $\frac{20}{8}$, $\frac{23}{11}$, $\frac{25}{1}$, $\frac{25}{2}$, $\frac{32}{58}$, $\frac{32}{59}$, $\frac{33}{8}$, $\frac{33}{51}$, $\frac{33}{52}$, $\frac{34}{2}$, $\frac{34}{29}$, $\frac{35}{37}$, $\frac{37}{3}$, $\frac{37}{27}$, $\frac{40}{5}$, $\frac{43}{4}$, $\frac{52}{1}$, $\frac{52}{8}$, $\frac{52}{19}$, $\frac{58}{1}$.]

This is in part Brontozoum isodactylum of the Ichnology. For the most part B. isodactylum is referable to Anomœpus intermedius.

Pachydactylous, tridactylous, unguiculate, tuberculate, ornithoid. Divarication of the lateral toes, 70° to 85°; do. of the inner and middle toes, 20°; of the middle and outer toes, 50°. Phalanges not well marked on any specimens in the Cabinet; but they doubtless correspond to those of other species of this genus, and the Grallator, of which more will be said subsequently. Length of the inner toe, 7 inches; of the middle toe, 8.5 inches; of the outer toe, 7 inches. Length of the step, 2 ft. 7 inches.

An outline of this track is shown on Plate IV., fig. 1. It approaches nearest to B. minusculum, but has a greater divarication of the lateral toes, and they are more nearly equal in length.

On a slab from Turner's Falls, (No. $\frac{23}{11}$ in the Cabinet,) are several tracks corresponding in shape to the B. divaricatum, but much smaller. It is probably a distinct species, but I refer to it here as a variety, since the tracks have not the distinctness and perfection desirable to settle such questions.

6. Grallator parallelus. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{28}{1}$, $\frac{49}{2}$, $\frac{51}{6}$, $\frac{52}{4}$, $\frac{54}{1}$, $\frac{54}{5}$, $\frac{54}{8}$, $\frac{55}{110}$.]

Pachydactylous, tridactylous, unguiculate, tuberculate, ornithoid, plantigrade; the track showing the heel bone. Divarication of the lateral toes, 20° to 25°. Phalanges, 2, 3, 4. Heel bones, three on the track. Length of the inner toe, 3 inches; of the middle toe, 5.8 inches. Of the outer toe, 3.5 inches; of the foot, 7 inches; of the step, 40 inches.

An outline of this track of the natural size, is shown on Plate V., fig. 1. Fig. 2 is probably Brontozoum Sillimanium, although defective in the extremity of the middle and outer toe; this figure is given because it shows a heel bone behind the inner as well as the outer toe.

This species differs from G. cursorius by its much larger size and stouter proportions, while its stride is less. Size chiefly distinguishes it from Brontozoum Sillimanium.

From the other species of Grallator it differs by the smallness of its divarication in the lateral toes. Not uncommon, but not abundant at Turner's Falls.*

7. Leptonyx lateralis, (λεπτός narrow, and ὄνυξ a claw.) (Nov. Gen. and Sp.)

[In the Cabinet, Nos. $\frac{47}{40}$, $\frac{47}{51}$.]

Very pachydactylous, tridactylous, unguiculate, tuberculate, ornithoid. Divarication of the lateral toes, 60°. Length of the toes 0.65, 0.95, 0.65 inch; of the heel bone, or a prolongation of the outer toe, 0.1 inch. Claws narrow and relatively long; on the outer toes apparently proceeding from the outside of the toe.

We have but two insulated specimens of the tracks of this small species, but they are so peculiar that I have ventured to give them a name. It comes from Turner's Falls, and is shown on Plate V., fig. 3. This of course is a new genus as well as species.

* Grallator gracilis. (Nov. Sp.)

[Specimens in the Cabinet, Nos. $\frac{17}{2}$, $\frac{17}{3}$, $\frac{17}{4}$, $\frac{23}{8}$, $\frac{28}{7}$.]

In the course of my examination of the slabs in the Cabinet, I have found several examples of ichnites which could not readily be referred to any described by my father. Generally the odd examples have been referred to the nearest known species, either with or without a query. But it seems manifestly unjust to pass by one delicate species of Grallator in this way—the smallest species known of the thick-toed birds—and therefore I venture to describe it as a new one, with the specific name of gracilis. It should be mentioned too, that my father was unable to refer it satisfactorily to any known species, and intimates in his notes that it may be a new species.

Description.—Divarication of the lateral toes, 35°; of the inner and middle toes, 22°; of the middle and outer toes, 14°; of the claws and axes of the toes, 10°; of the axis of the foot with the median line, 5° to 8°. Distance of the middle of the heel from the median line, 0.6 inch. Length of the inner toe, 0.85 inch; of the middle toe, 1.3 inch; of the outer toe, 1 inch; of the foot, 1.8 inch; of the middle toe beyond the others, 0.7 inch; of the step, 11 to 12 inches. The inner toe does not extend as far forwards as the outer, by 0.2 inch. Distance between the tips of the lateral toes, 0.95 inch; between the inner and middle toes, 0.9 inch; between the middle and outer, 0.8 inch. Length of the first phalanx of the inner toe, 0.35 inch; width of do., 0.2; length of the second phalanx with the claw, 0.5 inch; length of the first phalanx of the middle toe, 0.45 inch; width of do, 0.25 inch; length of the second phalanx, 0.35 inch; length of the third phalanx and claws, 0.5 inch; average length of each of the first three phalanges of the outer toe; 0.25 inch; width of the same, 0.2 inch; length of the fourth phalanx and claw, 0.35 inch. Length of the claws, 0.1 inch. Width of the trackway, 1.6 inch.

Outline of this species shown on Plate IX. fig. 7. A second row of this species upon No. $\frac{23}{8}$, shows a slight slipping of the heel, as if the animal was walking down a slight slope, and thus producing three ridges. One part of the heel is always the most prominent, in correspondence with what has been elsewhere observed respecting the heels of the thick-toed birds. Other rows of tracks similar to this species appear on this slab, but the divarication of the lateral toes is much greater and the stride smaller. They are more like G. tenuis. G. gracilis differs from G. tenuis by the much smaller size, the greater length of step and the greater proportionate length of the outer toe.

Locality.—On dark red sandstone, at the Ferry above Turner's Falls, in company with Brontozoum Sillimanium, Antipus bifidus, Plesiornis quadrupes, Anisopus gracilis, Unisulcus minutus, and Apatichnus circumagens.—*C. H. H.*

8. COMPTICHNUS OBESUS, (κομψός, elegant, and ἴχνος, track.) (Nov. Gen. and Sp.)

[In the Cabinet, Nos. $\frac{55}{5}$, $\frac{55}{41}$.]

I cannot refer the tracks of this species to any known genus, and therefore create a new one, founded on the sleek and beautiful appearance of the track.

Hind Foot.—Pachydactylous, tetradactylous, digitigrade, without tubercular expansions, and with very short if any, claws. Divarication of the three outer toes, that is, of the outside toes of the three, 40°. Length of the toes, reckoning outward, 0.25, 0.35, 0.5, 0.4 inch; of the foot, 0.6 inch; of the step, 2.6 inches. Width of the trackway, 1.5 inch. Axis of the foot, divergent outward from that of the trackway, about 10°.

Fore Foot.—Tetradactylous, toes nearly circular on the bottom; three front ones somewhat elongated, and their axes divergent, hind toe circular; the whole track resembling one made by a living quadruped, such as a dog or cat. Position of the track a little in advance of the hind foot, and on the inside. Length of the track 0.3 inch.

An outline of our best specimen of this species is shown on Plate V., fig. 4. A photographic sketch of the same is given on Plate XVIII., fig. 6. The species (from Turner's Falls) is peculiar in being very thick toed, yet showing no protuberances, and scarcely any claws.

9. TRIHAMUS ELEGANS. (*Trias* and *Hamus*, a hook.) (Nov. Gen. and Sp.)

[In the Cabinet, No. $\frac{47}{30}$.]

Bipedal, (?) leptodactylous, palmigrade, tridactylous. Divergence of the lateral toes, 70° to 80°. Toes near their extremities, bent inward toward the line of direction as much as 20°. Heel large, broad, rounded behind, making an impression as deep as the toes. Length of the toes, reckoning outward, 0.6, 0.75, 0.9 inch; of the heel, 0.3 inch; of the foot, 1.15 inch; of the step, 5.2 inches. Breadth of the heel, 0.5 inch.

An outline of the only good specimen we have of this species, is shown on Plate II., fig. 3.

I could not refer the track to any known genus, and therefore propose a new one, named from the hooked character of the toes. The foot being tridigitate, has an ornithoid aspect, but the large heel, the hooked character of the toes, and the strong inward curvature of the feet, look rather like the lizard type. It occurs at Turner's Falls.

10. ANTICHEIROPUS HAMATUS, (ἀντίχειϱ, the thumb, and ποὺς, the foot—the *thumb-foot.*) (Nov. Gen. and Sp.)

[In the Cabinet, No. $\frac{51}{17}$.]

The characteristic peculiarity of the foot of this genus, is, that one of the three front toes stands out at such an angle as to make it look like a thumb, while the two other toes are much less divaricate. The thumb and outer toe make an angle of more than 100°, and with the middle toe, of about 90°. The divarication of the other two toes is from 20° to 40°. But this angle is very difficult to measure because the toes curve so much. We have only one row of three tracks in the Cabinet, and although they differ in some particulars, there is so much of general resemblance as to identify them, and to mark off this as distinct from other genera and species. It has some resemblance to the Tarsodactylus, for in a prolongation backwards of the outer toe, at the distance of two inches, is an elongated impression evidently made by a toe articulated high up the tarsus. But the other parts of the foot bear no resemblance to that of the Tarsodactylus.

The length of the hindmost track is a little short of 6 inches, and the distance between the tips of the lateral toes, 5.5 inches. The length of the second and third tracks is 7 inches; and the distance between the tips, 8 inches. The stride between the first and second tracks is 14 inches; between the second and third, 30 inches. My opinion is, though I cannot certainly prove it, that the first track was made by a fore foot, and the two other tracks by a hind foot. Plate IX., figs. 1 and 2, show an outline of the two first tracks, not placed however in a normal position.

The only specimen we have is from Turner's Falls. But its examination brought to recollection a very large single specimen, that had been in the Cabinet for twenty years from Marsh's quarry in Montague, but which I had never ventured to describe, because I supposed it might be a distorted track of some other species. But it is obviously an Anticheiropus, and as we have not only a distinct track but a fair counterpart, I give it as follows:

11. ANTICHEIROPUS PILULATUS. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{10}{4}$, $\frac{10}{5}$.]

Divarication of the lateral toes, 90°; of the two outer ones, 15°. Length of the foot as shown on the outline sketch, Plate IX., fig., 3, is 21 inches. The pellets are large and distinct, and on the depressed track, the middle one is apparently separated half an inch from the toe, as if there were a deep furrow between them. But on the underside of the track, which is that from which our drawing was taken,

they coalesce. The toes on the sketch are wider than on the upper side, on the depressed track; but they are no longer, except perhaps the pellets. The under side was sketched rather than the upper, because upon the whole, more complete; and because along its middle there is a ridge following the lines of dots, a very unusual if not unique feature. The slope from the ridge is uniform to the edges of the toes, so that the bottom of the toe is a synclinal trough and not a semi-cylinder, which is the usual form. As it is a left hand track, I have so represented it, and the eye is supposed to be placed above it on the depressed or upper side, looking down to the bottom of the depression.

The heel is double, or rather there are two heels; the thickest swelling out on the lower side of the huge thumb, yet in fact lying behind the principal or middle toe; and sloping upward as it does on its backward prolongation, it looks like the impression of a tarsal or tarso-metatarsal bone. The other and smaller heel seems to be a backward prolongation of the outer toe, and dies away so gradually that it is difficult to say where it terminates. This may have been made by a process of the tarsus.

The large pellets remind one of the huge Otozoum, but the entire absence of phalangeal or other rounded protuberances on the under side of the foot, although the rock is very favorable for exhibiting them on the track, and the presence of a ridge, show that the two genera are quite distinct.

About five inches outside of the thumb is an indentation about an inch across, which was probably made by the extremity of a fourth toe, as in the Tarsodactylus. It is shown on the drawing. I should not have connected it with the track did I not find it in the A. hamatus.

This strange species of track was found at Marsh's quarry at Montague, where the first tracks that turned my attention to Ichnology, were obtained twenty-eight years ago.

12. Exocampe minima. (Nov. Sp.)

[In the Cabinet, No. $\frac{16}{4}$, $\frac{55}{4}$.]

This species differs from the Exocampe ornata, described in the Ichnology, chiefly by its diminutive size and slenderer proportions. It is unnecessary to give measurements of the parts, as the whole, both hind and fore feet, are shown in the photograpic sketch, Plate XVIII., fig. 3, of the natural size. I have no great confidence in this as a new species, but the probabilities are so strong that it is such, that I let it stand. It comes from Turner's Falls, but is not common. [*See Appendix.*]

13. Harpedactylus crassus. (Nov. Sp.)

[In the Cabinet, No. $\frac{47}{53}$.]

Hind Foot.—Heel and toes thick and elegantly curved; tetradactylous, lacertiloid. Inner toe shortest, its chord 0.8 inch. Second toe longest, its chord 2.1 inches. Third toe less curved, its chord 2.1 inches. Fourth toe curved outward, its chord 1.6 inch. Versed sine of the toes, reckoning outward, 0.25, 0.3, 0.25, 0.25 inch. Thickness of the heel 0.65 inch (its length not shown on the only specimen we possess.)

Fore Foot.—Pentedactylous; heel stout and thick; toes stout and not much curved; the inner one set somewhat back on the heel. Thickness of the heel, 0.55 inch. Both hind and fore feet palmigrade.

An outline of this species is shown on Plate III., fig. 1, taken from our only specimen. The tracks are here brought to light by grinding down and smoothing the surface, which when wet shows the tracks beautifully, though perhaps the parts are thus made rather too thick. The tracks of two other species of animals are shown on the same specimen.

14. Harpedactylus gracilior. (Nov. Sp.)

[In the Cabinet, Nos. $\frac{47}{52}$, $\frac{55}{1}$.]

Hind Foot.—Leptodactylous, tetradactylous, three inner toes gracefully curved inward, the fourth slightly outward; lacertiloid. Divarication of the outer and second toes, 90° to 100°. Length of the toes, reckoned outwardly, 0.3, 0.7, 0.9, 0.7 inch; of the heel, 0.75 inch; of the foot, 1.6 inch; of the step, 3.5 inches.

Our specimens do not show a fore foot; but the hind foot shown on Plate III., fig. 2, sketched from our best specimen, is so like a Harpedactylus that I cannot doubt that the animal had a fore foot. It comes from Turner's Falls.

15. Toxichnus inæqualis, (τοξόν, a bow, and ἴχνος, a track.) (Nov. Gen. and Sp.)

[In the Cabinet, Nos. $\frac{55}{3}$, $\frac{55}{33}$.]

Both Feet.—Leptodactylous, tetradactylous, digitigrade, toes all gracefully curved inward, except the innermost, which is nearly straight.

Hind Foot.—Length of the toes reckoned outward, 0.7, 1.7, 1.35, 1 inch. Versed sine of the longest, 0.2 inch. Length of the foot, 1.7 inch; of the step of the same foot, 9.7 inches.

Fore Foot.—*On one specimen,* tridactyle, toes nearly straight. Length, reckoning outwardly, 0.8, 1.3, 1.1 inch; of the foot, 1.6 inch; of the step of the same foot, 9.3 inches. *On another specimen the impressions quite perfect;* Tetradactylous. Length of the toes, reckoning outwardly 0.25, 0.6, 0.75, 0.6 inch.

This last specimen, which is very much smaller than the other, as to the fore feet, I think may have been impressed by a distinct species. But as the hind foot is as large, I do not separate them, especially as I feel some doubts whether I have got hold of the exact characters of the species. An outline of the second specimen, (or a part of it,) is shown on Plate V., fig. 5, also a hind foot of the first specimen, on fig. 6; but the toes must be distorted.

The want of a heel running backwards from the toes on these tracks, makes it necessary to separate them from the Harpedactylus. The Figures suggested the above name, from their resemblance to a bow. From Turner's Falls. The specific name refers to the unequal size of the feet.

TRACKS OF INSECTS.

In my Ichnology, I put into one and the same group, the tracks of Crustaceans, Myriapods and Insects, because I could not in all cases distinguish the different classes by their tracks. In that group, however, I described six species which I had little hesitation in calling insects, because they had six feet with single linear or nearly linear extremities, which were arranged in walking as those of insects would be; and it seems to me still, that the inference was a fair one. But in the same group I placed six other species, some of which did not appear to have but two, and some only four feet, that made single linear impressions. Yet on one or two specimens, I thought I discovered the traces of two other small feet, that only occasionally left an impression, and I suggested in the Ichnology, that probably all of these species had six feet, but that only two or four of them left permanent traces. This suggestion is fully confirmed by several other specimens recently purchased. The first specimen on which I noticed the feet was one of Acanthichnus cursorius, (No. $\frac{47}{80}$, of the Cabinet,) of which a sketch is given on Plate VI., fig. 1. Here we have the two prominent rows of tracks, which have been supposed to characterize the Acanthichnus. But two other rows are seen occasionally outside of the others, and placed almost at right angles to the line of direction, and now and then, if I mistake not, we have the impression of a third foot. The same thing appears on other specimens of Acanthichnus as for instance, Plate VI., fig. 6; also on many specimens of Bifurculipes, as figs. 7, 8 and 9, in Plate VII. But the two principal rows of linear track is a common character with several genera, as for instance the Lithographus and Copeza, as figs. 14 and 15, Plate VI.; also in the Hexapodichnus figured in the Ichnology; Plate XXIX., fig. 7, and XXX., fig. 1. The largest of the hexapod impressions is the Grammepus erismatus. Even the Conopsoides I think will turn out to have had six feet, although usually only two made an impression. But sometimes four are very distinct, as in fig. 4, Plate VI.

In my Ichnology, I have given a species of track under the name of Acanthichnus tardigradus, a small portion of which I copy in this paper on Plate VII., fig. 3; but which now seems to me more probably a Myriapod. I have, therefore, given it a new name. *Pterichnus centipes*, (from πτερόν a feather, which the track resembles,) taking it out of the genus Acanthichnus.* I am in doubt, also, about the Biferculipes scolopendroideus (Plate XXVII., fig. 1, of Ichnology,) whether that, also, is not a Myriapod. Yet I shall let it stand among the insects on account of its general resemblance as to the form and position of the feet to what it seems to me living insects show.

The Saltator caudatus and bipedatus (Plate XXIV., figs. 8 and 9, Ichnology,) appear most probably to have been insects; but I leave them out in my present enumeration.

If the other varieties of Acanthichnus figured in the Ichnology, are insects, or if some other minute animals, it seems to me I might reasonably refer them to a greater number of species than I have done. To show the probability of this opinion, I have brought into juxtaposition on Plate VI., figs. 1, 5, 6, 7, 8, 18, 9, 10, 11, 12, 13, 2, most of the varieties of Acanthichnus, showing the width of the trackways, the position and length of the feet, and the step or leap, and sometimes the alternation of the step; and may I not safely presume that no entomologist would hesitate to refer them to several species? In the Ichnology I have referred, figs. 5, 7, 18 and 8, to A. cursorius, although they differ so widely as to the length of the stride or leap; for I find that this varies very much sometimes in the same series of tracks. The distinct alternation of the parallel rows of tracks, I must regard as a good specific character, although there is some irregularity in this respect when the steps are short. Partly on this ground and partly on the greater width of trackway and the shortness of the feet, I propose for fig. 5, the name of *A. alternans*. Fig. 6, generally shows the same characters, and the outside row of tracks standing at right angles to the trackway have so much the aspect of oars or wings, that I propose for it the name of *A. alatus*. We have only one specimen of fig. 4, Plate VII., which has the unique character of exhibiting a serpentine trackway, while the tracks on the sides are so near as to exhibit almost uninterrupted lines. I propose for it the name of *A. anguineus*. Outside of the principal rows of tracks numerous minute impressions indicate other feet, yet they do not show any regular succession and may not belong to the track. Plate VI., fig. 11, shows in some places a line of tracks along the middle of the trackway, and in all the rows the tracks almost touch.

* In the Cabinet, Nos. $\frac{36}{19}$, $\frac{36}{27}$, $\frac{36}{47}$.

Though our specimens of this species are not very good, I call it *A. trilinearis.* Fig. 13 shows evidently a distinct species—probably a different genus, which has an alternation of very minute linear feet and small punctures, nearly on a line, and hence may appropriately be named *A. punctatus.* The pairs of these minute feet—often they are in triplets—are sometimes all linear, as on fig. 2, and must make another species, that might take the name of *A. rectilinearis.* If the spreading character of two rows of tracks shown on the right-hand side of fig. 10, Plate VII., does not indicate a species of Myriapod rather than insects, it should evidently take the name of *A. divaricatus.* In the Ichnology, the name *A. saltatorius* is given to figs. 9, Plate VI., (copied from a new specimen,) also 10 and 12, on account of the lateral movement which the animal appears to have made like a dancer. This track is yet a puzzle.

I incline to strike out Bifurculipes tuberculatus, from the probability that the tubercles which are all of the track that remains, are in fact only the more persistent part of the original track; the little elevation of the mud, produced by the animal's tread, while the linear part has been worn away; for sometimes it remains. I have added one species of Bifurculipes, the *B. curvatus,* distinguished by the great curvature of the toes, as in figs. 2 and 9, Plate VII.

I have become convinced that the Copeza and Lithographus of the Ichnology are so nearly alike that they may be united. I propose to drop Lithographus and retain Copeza. The C. triremis is remarkable for the great width of the trackway. The Lithographus hieroglyphicus, Plate VII., figs. 1 and 10, has one not half as wide! and I would call the species *Copeza propinquata.* The *L. cruscularis* has the narrowest trackway of any species I have found, and as its three feet on the track are often placed so as to resemble a single crooked leg, I would retain the name *C. cruscularis.* To these I must add a fourth species, new and quite distinct, shown on Plate VI., fig. 14, and perhaps, also, on figs. 13 and 15. On this (14) all the impressions except the two principal rows, are little more than mere punctures, and hence I give the name of *C. punctata.*

As to the two species of Hexapodichnus in the Ichnology, their insect characteristics cannot escape observation. The Conopsoides may be a little more doubtful especially as no specimen described in the Ichnology showed more than three rows of tracks. But a specimen recently obtained, and which is figured on Plate VI., fig. 4, has four most distinct rows, and on one side, as the figure shows, a third row occasionally manifests itself, and thus is the genus brought into the class of insects whose usual number of feet is six. Fig. 4 differs from those shown in the Ichnology, in that the feet are not more than half as long; hence I make a new species of it, under the name of *C. curtus.*

I feel obliged to add at least two new genera to those Lithichnozoa which I regard as insects. One is the Harpepus, shown on Plate VII., fig. 6, from ἅρπη a sickle. At least one of the rows of tracks shows a delicately curved foot, one end of which is blunt, or rather it has formed a raised and blunt extremity on the track, which may well represent the handle of the minute sickle, proceeding from it. Some specimens seem to indicate that two of the feet possess these characters so as to make two rows of these curved tracks, as is seen on fig. 6. The curve of the sickle is generally very fine like a hair, and hence the specific name *capillaris*.

Sagittarius, (the Archer,) is the name given to another genus, represented on Plate VI., fig. 3. As yet, I have found only two parallel rows of delicately curved tracks, with their concave sides towards each other, looking like so many small bows, which suggested the name. Doubtless there were other feet, but our specimens are few, and the impressions not deep. The bows alternate with each other, and hence the specific name, *S. alternans*. It is photographed on Plate XVIII., fig. 5.

According to these views, the species of Lithichnozoa, which I should now regard as insects, are the following. Numbers in brackets indicate the new species, which I now propose, and are a continuation of the new species already described. I give also the references to the specimens in the Cabinet.

Grammepus.

1. erismatus, Nos. $\frac{9}{13}$, $\frac{12}{2}$, $\frac{26}{21}$, $\frac{36}{37}$, $\frac{36}{39}$, $\frac{47}{12}$, $\frac{47}{14}$, $\frac{47}{18}$, $\frac{55}{36}$.

Acanthichnus.

2. cursorius, Nos. $\frac{36}{19}$, $\frac{36}{21}$, $\frac{36}{27}$, $\frac{36}{29}$, $\frac{36}{30}$, $\frac{36}{32}$, $\frac{36}{45}$, $\frac{47}{64}$, $\frac{47}{65}$, $\frac{47}{76}$, $\frac{47}{77}$, $\frac{47}{80}$, $\frac{55}{15}$, $\frac{55}{42}$, $\frac{55}{51}$, $\frac{55}{60}$, $\frac{55}{81}$, $\frac{55}{86}$, $\frac{55}{87}$, $\frac{55}{89}$, $\frac{55}{104}$.
3. alternans, No. $\frac{55}{59}$. [16.]
4. altatus. [17.]
5. anguineus, No. $\frac{55}{50}$. [18.]
6. trilinearis, Nos. $\frac{36}{35}$, $\frac{52}{14}$. [19.]
7. punctatus. [20.]
8. rectilinearis. No. $\frac{55}{113}$. [21.]
9. divaricatus. [22.]
10. saltatorius, Nos. $\frac{36}{27}$, $\frac{36}{31}$, $\frac{36}{34}$, $\frac{55}{48}$, $\frac{55}{68}$, $\frac{55}{75}$.

Bifurculipes.

11. laqueatus, Nos. $\frac{36}{28}$, $\frac{36}{33}$, $\frac{36}{48}$, $\frac{55}{44}$, $\frac{55}{52}$, $\frac{55}{55}$, $\frac{55}{58}$, $\frac{55}{74}$, $\frac{55}{86}$, $\frac{55}{88}$, $\frac{55}{96}$, $\frac{55}{102}$.
12. scolopendroideus, Nos. $\frac{36}{14}$, $\frac{36}{41}$.
13. curvatus, Nos. $\frac{55}{62}$, $\frac{55}{65}$, $\frac{55}{66}$, $\frac{55}{90}$, $\frac{55}{91}$, $\frac{55}{98}$. [23.]
14. elachistotatus, Nos. $\frac{36}{17}$, $\frac{55}{56}$, $\frac{55}{82}$, $\frac{55}{70}$, $\frac{55}{92}$, $\frac{55}{97}$, $\frac{55}{98}$.

Copeza.

15. triremis, No. $\frac{36}{7}$.
16. propinquata, Nos. $\frac{36}{18}$, $\frac{36}{19}$, $\frac{36}{26}$, $\frac{55}{42}$, $\frac{55}{43}$, $\frac{55}{54}$, $\frac{55}{64}$, $\frac{55}{105}$. [24.]
17. punctata, No. $\frac{36}{45}$. [25.]
18. cruscularis, Nos. $\frac{36}{17}$, $\frac{55}{73}$, $\frac{55}{78}$.

Hexapodichnus.

19. magnus, Nos. $\frac{36}{11}$, $\frac{55}{45}$.
20. horrens, Nos. $\frac{36}{24}$, $\frac{36}{33}$.

Conopsoides.

21. larvalis, Nos. $\frac{36}{25}$, $\frac{55}{57}$, $\frac{55}{67}$, $\frac{55}{80}$.
22. curtus, Nos. $\frac{55}{44}$, $\frac{55}{53}$, $\frac{55}{69}$, $\frac{55}{70}$, $\frac{55}{92}$. [26.]

Harpepus.

23. capillaris, Nos. $\frac{55}{49}$, $\frac{55}{99}$. [27.]

Sagittarius.

24. alternans, Nos. $\frac{55}{72}$, $\frac{55}{94}$. [28.]

Twenty-four species of insects is a large number, but I think my specimens would justify a larger number; and if insects existed during our sandstone days, and that rock be Jurassic, we might expect this class of animals to abound.

My chief doubt as to the insect character of the preceding tracks, results from the leaning of several eminent Zoölogists to the opinion that they might rather have been made by minute crustaceans.

Profs. AGASSIZ, DANA and LEIDEY, founded their opinion upon the drawings in my Ichnology, without having seen specimens, and they feel by no means confident. Prof. AGASSIZ, however, sent me several sketches of the tracks of a small living crustacean, the Ocypode arenaria, which he copied from the sand of the coast in Florida. Copies of these are given on Plate VIII., figs. 1, 2, 3, 4, 5, 6 and 7. One cannot but be struck with the great want of resemblance between these and the tracks which I regard as those of insects. But they do greatly resemble the Protichnites described by Sir WILLIAM LOGAN on the Potsdam sandstone of Canada. The general presence of a tail trace, and the ovoid form of the tracks, form very marked distinctions between these and the insect tracks of this paper.

TRACKS OF MYRIAPODS.

How many of the species of the Ichnology may be referred to this class with confidence, I feel incompetent to decide. The Acanthichnus tardigradus, however, which I have changed to Pterichnus centipes, does seem most probably to be a Myriapod. I venture to add the following, hitherto undescribed, and whose true nature I may have mistaken, since the tracks, although numerous, are somewhat obscure from the character of the shale on which they are impressed.

29. LUNULA OBSCURA. (Nov. Gen. and Sp.) Plate II., fig. 6.

[In the Cabinet, Nos. $\frac{36}{45}$, $\frac{52}{12}$, $\frac{52}{14}$.]

This genus is characterized in its track by a narrow axis, on both sides of which are lunate impressions, extending laterally so as to make the trackway from 0.5 to 0.8 of an inch wide, looking like the rachis of a plant, with small lunate leaves, extending from 0.15 to 0.25 of an inch along the stem as thickly in fact, generally, as they can be placed. The front part of the leaflet (track) makes a much deeper impression than the posterior part, which, in fact, has no distinct outline, but is shaded off into the subsequent track. In a few instances the track appears somewhat bifid.

It is possible this impression is a plant; but it looks rather like a track to me, and I have imagined that it might have been formed by a Myriapod, first stretching itself out at full length and then drawing forward its posteriors by their vertical

elevation, and afterwards throwing its anterior part ahead by a similar movement. We might suppose that this could not be done, without obliterating the impressions of the numerous feet; but we have specimens in the Ichnological Cabinet, where an annelid has left on clay, continuous rows of setæ or feet, and a central trail, all perfectly preserved, showing that somehow or other these animals have the power of so moving forward, as to leave what seems an unbroken succession of the impressions of their bodies and feet, as if the animal had been lifted up and laid down continuously. Our specimens a good deal resemble these remarkable impressions (*Nereites*) on the clay slate of Waterville in Maine, which have been described by Prof. Emmons and others under various names. Our specimens are on fine red micaceous shale from Turner's Falls.

TRAILS OF ANNELIDS.

I think we can speak of several of these with more confidence than in regard to Insects or Myriapods, because the latter animals are for the most part destitute of feet, unless it be sometimes slight protuberances along the under side of the body. The Ichnology describes ten species of Annelids, which I am still disposed to regard as reliable. To these I now add two other species, which fall under new genera.

30. Bisulcus undulatus. (Nov. Gen. and Sp.)

[In the Cabinet, Nos. $\frac{10}{6}$, $\frac{20}{9}$, $\frac{32}{60}$, $\frac{52}{11}$, $\frac{55}{76}$.]

In the Ichnology, I have described three species of Annelids under the name of Unisulcus, where a single groove only is left, resembling exceedingly those left by the earth-worm so frequently in summer on mud. In the Bisulcus, there are two grooves with a ridge between them. The specific name of the only known species, merely indicates the serpentine course of the trail, looking like sections of waves. Plate III., fig. 5, is a poor representation of the Bisulcus.

31. Trisulcus laqueatus. (Nov. Gen. and Sp.)

[In the Cabinet, Nos. $\frac{52}{12}$, $\frac{52}{14}$.]

We have in this genus three grooves with two intermediate ridges. Sometimes the ridges show slight protuberances, like those of the Sphærapus of the Ichnology, indicating protuberances on the under side of the ridges of the animal's body, as they are sometimes found in Annelids. In moving forward, the animal sometimes turned back and crossed its own track, so as to form graceful loops, and hence the specific name of the only species yet found. It is shown on Plate III., fig. 4, which shows imperfectly, also, the protuberances on the ridges of the track.

The two last genera, and indeed all the species remaining to be described, have been found only at Turner's Falls.

SPECIMENS OF DOUBTFUL ORIGIN AND CHARACTER.

A few specimens remain undescribed, which I have examined with great care, and upon the whole, have a pretty strong conviction that they are tracks; but some doubts always cross my mind when I look at them. For convenience I give them names, but except in one instance I refrain from attempting to refer them to any known classes of animals.

32. Grammichnus Alpha. (Nov. Gen. and Sp.)

[In the Cabinet, No. $\frac{47}{13}$,]

Grammepus, which is one of the genera of the Ichnology, implies that the *foot* has the form of letters; but *Grammichnus* means that the *track* has that form. This is the true idea, and I could wish that some other name were substituted for Grammepus. But the G. erismatus and uniordinatus certainly differ generically from the Grammichnus we are about to describe. The G. uniordinatus is certainly a different genus from either.

If the Roman capital A, or the Greek Alpha was laid down in succession along a straight line and at right angles to the line, and the letters were connected by a sort of triple hyphen, it would give a tolerably good representation of the genus and species Grammichnus Alpha, as a reference to Plate III., fig. 3, copied from the only good specimen we possess of the track of this species, will show. It ought to be added that the left leg of the Alpha shows certainly as many as five protuberances. The same is seen less distinctly on the right leg, especially near its lower end, and also more or less on the hyphens.

These facts show the origin of our name, but they do not furnish any clue to the nature of the animal, or make it certain that it is not of vegetable origin.

33. Ampelichnus sulcatus. (*Grammepus uniordinatus of the Ichnology.*) (Nov. Gen.)

[In the Cabinet, No. $\frac{36}{38}$.]

This genus is more obscure than the last. It consists on the track of grooves rarely more than a quarter of an inch, sometimes half an inch long, about the twentieth of an inch broad, arranged somewhat in a rachis form. Most usually these grooves are by pairs, as if made by a bipedate animal; but sometimes the number is greater, and the impression has the aspect of the stem and clusters of the grape; and hence the name (ἄμπελος, a vine.)

Plate VI., fig. 16, gives some idea of this track from the best specimen in the Cabinet. Possibly it may be a plant.

34. Climacodichnus corrugatus. (Nov. Gen. and Sp.)
(κλιμακώδης, like a ladder. *Corrugatus*, wrinkled.)

[In the Cabinet, Nos. $\frac{33}{57}$, $\frac{47}{20}$, $\frac{47}{21}$, $\frac{47}{22}$, $\frac{55}{7}$.]

The aspect of all the specimens of the tracks of this species (of which we have several very distinct and fine ones in relief,) is an irregularly corrugated surface, crossed by several small ladder-like rows of impressions, a good deal resembling the steps of the Acanthichnus, but more than sufficient to form the sides of the ladder, and extending past one another. It is doubtful whether what appear to be cross-bars to the ladder, may not belong to the general corrugations of the surface, rather than the ladders. But they give to the parallel rows of what seem to be tracks, the aspect of ladders. The width of the ladders is about 0.39 inch, and the length of the individual tracks not usually much more than 0.2 inch. The ladders are not commonly straight, but curve to the right and the left, and sometimes cross one another, retaining their individuality very perfectly.

Now did these ladder-like rows of impressions cross a smooth surface of stone, I could not hesitate to regard them as tracks. But the corrugations of the whole surface, which certainly have a general resemblance to those of the impressions, lead me to hesitate and try to refer the whole to some other agency than animals, and plants are the only resort that I can think of, or possibly some freak of water, and there is on the right hand side of the photograph, Plate XIII., a straight impression, that looks like a plant, somewhat. But after all—and I have looked at these specimens perhaps hundreds of times—my mind generally comes to the conclusion that the parallel serpentine rows of impressions must be tracks, whatever may be the origin of the other corrugations.

The outline of these rows, given in Plate VII., fig. 5, conveys but an imperfect idea of their character. But the photograph in Plate XIII., is very fine; and is almost equivalent to having the specimen itself accompanying the paper. It is one-third the natural size.

35. Ænigmichnus multiformis, (αἴνιγμα, an enigma, and ἴχνος, a track. *Multiformis*, of many forms.) (Nov. Gen. and Sp.)

[In the Cabinet Nos. $\frac{27}{21}$, $\frac{44}{10}$, $\frac{51}{15}$.]

Of this enigmatical species of tracks, we have three large slabs, one of them three and a half feet by four and a half, and the others not much less; all of them

covered by thousands of small impressions, which are very distinct. Most of them were evidently made by the feet of animals, but of what kind we find it difficult to decide.

For a time it seemed almost impossible to give any description of these slabs that would be at all satisfactory. But so fine a photograph of the largest was obtained, that with a microscope, all the minute markings are very distinct, and the copies from it, which we give (Plate XIV.) I trust retain most of them. Besides this, we give on Plates I., figs. 4 and 5, XI., figs. 1–6, XII., figs. 1–4, numerous rows of impressions a few inches long and of the natural size of many of the varieties of form. By these means we trust scientific men will be able to form a tolerably correct idea of these anomalous markings.

On the largest slab from which the photograph was taken the following facts are manifest, as they are also on the other specimens.

1. Several perfectly straight, simple grooves or furrows, perfectly parallel and sometimes less than half an inch apart, resembling drift furrows; yet they are certainly not such, for the slab was split out of the quarry, and did not lie upon the surface. Probably they are independent of the rows of tracks; for though the two are nearly parallel, they sometimes cross at a small angle. If a carapace-like shell of some animal, however, had points in it projecting downward, they might have made the grooves as the animal dragged himself over the surface; but it is marvellous that they are made so perfectly straight and uninterrupted.

2. Numerous rows of impressions, not less certainly than thirty-five, running across the slab nearly parallel to one another and to the grooves, but as already stated, sometimes crossing at a small angle; and sometimes the rows of tracks are a little crooked.

3. The most usual form of these impressions is circular, as if made by a punch. These vary in diameter from mere points to nearly the fifth of an inch, and are approximately equidistant from one another. Sometimes they are elongated, and even become linear.

In one case, given on Plate I., fig. 4, there is a trifid arrangement of somewhat triangular toes, with two dents behind, and two or three on one side, and this arrangement is repeated about once in an inch. The axis of the foot in this case is turned aside from the line of direction as much as 30°; but I cannot decide in which direction the animal was moving, nor find a series of impressions to the right or left, corresponding to this one.

In another case there is a flask-like impression about an inch long, having on one side of the neck, three elongated impressions, and on the other side, at the

bottom of the flask, a circular dent, the whole being separated nearly as often as it can be, along the line of progression. This is shown on Plate XI., fig. 4. I have found no corresponding line of impressions to the right or the left.

In another case we have large indentations, say a third of an inch in diameter, arranged by pairs about two inches apart. See Plate XI., fig. 6. Another shows fine markings, almost as if a tuft of hair had been impressed upon the mud. See Plate XII., figs. 3 and 4.

4. Crossing this slab, and nearly parallel to the grooves and rows of tracks, may be seen three deeper and more irregular furrows, with small ridges on each side curving outward, and even crossing the specimen, so as to look like small ripple-marks, giving to the impression the aspect of the vane of a feather. The small side ridges are doubtless ripple-marks, produced by some solid body moving along against the current. I can hardly doubt that they were produced by the tails or tail-spines of some animal ploughing across the mud.

5. If this be a reasonable conjecture, it shows us which way the animals moved, and that they may have been covered with hard shells like some crustaceans, whose numerous small extremities made the rows of tracks and the processes along the margin of the shells, and the tail-spines made the parallel furrows.

In this case, I think the animals must have been as much as two feet wide. This conjecture is made more probable by a paper in a late number of the "Canadian Naturalist" by Dr. Dawson, "On the Foot-Prints of Limulus, as compared with the Protichnites of the Potsdam Sandstone." There is certainly some resemblanc between some of his drawings and ours, but not enough of likeness to justify us in bringing both the cases into a nearer relation than to refer them to the same general class of animals; and I more and more think that the markings on our specimens will be found to have had a crustacean origin.

MISCELLANEOUS ITEMS.

A large proportion of the finest tracks and rows of tracks now in our Cabinet, were obtained just as my Ichnology was passing through the press, or subsequently. Consequently many of the species in that work could now be described with much fuller and more satisfactory illustrations. But it would require expensive drawings, and I do not feel authorized to make much further appeal in this direction to the liberality of the Commonwealth, after having given so many illustrations which seemed to me indispensable. I shall therefore add only a few, hardly expecting that even these will not be set aside. Had I the funds requisite to obtain more good drawings of other fine rows of tracks, and the means were afforded for their

publication, I could add a large number to the engraved representations that have been given to the public. This will doubtless be done at some future time.

Brontozoum giganteum.

In my Ichnology I have given three inches as the maximum width of the toes of this species, and though we had in the Cabinet, specimens with toes considerably wider, the opinion was expressed that the surface exhibited was beneath that on which the animal trod, and might therefore show a track wider than the animal's foot by the bending downwards of the layers of mud. But among more recent specimens we have some that show toes full four inches across, and yet all the phalanges (except the fourth in the outer toe, agreeably to the views presented in this paper,) are distinct, and every mark to indicate that there is no distortion or exaggeration, and therefore this enormous size was attained by some individuals of this species. An outline of our best specimen is given on Plate X., fig. 1.

By the side of this I have placed on the same Plate, fig. 2, the drawing of another specimen, the representative of another variety not uncommon, whose outlines are very distinct, though the phalanges are not usually marked, which show so much slenderer proportions in every part, that it seems most likely it must be another species. No mere difference of age in the animals could explain the striking differences in the tracks. I have not proposed the slenderer species as new, because unwilling to add more to the list. But if we take the thick-toed specimen as the type of B. giganteum, the others may properly be called B. approximatum.*

* The above suggestion having been acted upon in the labelling of the Cabinet, I propose to give the descriptions of both as *different species*, with the usual references. No. $\frac{45}{8}$ was used as the type of B. giganteum.—C. H. H.

BRONTOZOUM GIGANTEUM. (Synonyms same as in Ichnology.)

[In the Cabinet, Nos. $\frac{2}{1}$, $\frac{2}{3}$, $\frac{2}{4}$, $\frac{2}{5}$, $\frac{2}{7}$, $\frac{7}{1}$, $\frac{8}{1}$, $\frac{9}{10}$, $\frac{9}{11}$, $\frac{15}{1}$, to $\frac{15}{5}$, $\frac{15}{8}$, $\frac{15}{11}$, $\frac{15}{14}$, $\frac{15}{16}$, $\frac{15}{18}$, $\frac{16}{6}$, $\frac{17}{1}$, $\frac{20}{6}$, $\frac{29}{1}$, $\frac{31}{22}$, $\frac{43}{1}$, $\frac{43}{2}$, $\frac{44}{1}$, $\frac{44}{2}$, $\frac{44}{3}$, $\frac{45}{1}$, $\frac{45}{3}$, $\frac{45}{4}$, $\frac{45}{8}$, $\frac{45}{9}$, $\frac{51}{11}$, $\frac{53}{3}$, $\frac{53}{6}$, $\frac{53}{8}$, $\frac{53}{11}$, $\frac{53}{12}$.]

Divarication of the lateral toes, 40°; of the inner and middle toes, 18° to 20°; of the outer and middle toes, 22°. Length of the middle toe, 10 inches; of the inner toe, 9 inches; of the outer toe, 8 inches; of the foot, 15 to 18 inches; of the step 4 to 5 feet. Width of the toes, 3 to 4 inches; of the posterior part of the foot, 7.5 inches. Length of the claw, 1 inch. Distance between the tips of the lateral toes, 10 inches; between the tips of the outer and middle toes, 7.5 inches; between the inner and middle toe, 6 inches. Length of middle toe beyond the others, 3.5 inches; of the first phalanx of the inner toe, 3.75 inches; of the second, 3.1 inches; of the first phalanx of the middle toe, 3.75 inches; of the second, 3 inches; of the third, 2.9 inches; of the first phalanx of the outer toe, 2.25 inches; of the second, 1.75 inches; of the third, 1.50 inches; of the fourth, 1.25 inches. Angle made by the axis of the animal's foot with the median line, or line of direction, as it walked, 0° to 10°. Distance of the centre of the heel from the median line, 0 to 5 inches. Width of the trackway, 18 inches. Toes nearly straight; middle one slightly curved inwards. Claws nearly straight, and only slightly curved downwards. Integuments of the under side of the foot, papillary and striated. Animals gregarious.

Papillary Impressions.

Specimens showing the papillary impressions are exceedingly rare; but we have now several beautiful ones in the Cabinet; and perhaps, upon the whole, the best specimens are the large ones that have been described in this paper, and figured on Plate XV., figs. 1 and 2. But we also have at least two good specimens of the Brontozoum minusculum, one from Wethersfield, Connecticut, which shows striæ as well as papillæ; the other a very beautiful specimen from Turner's Falls, figured on Plate XVI., fig. 1, one-fourth of the natural size.

Plectropterna gracilis.

So beautiful and perfect a row of the tracks of this species was lately obtained, that I could not resist the temptation to have it photographed, and it is given on Plate XVII., fig. 1. (In the Cabinet, No. $\frac{51}{19}$.) This may be compared with the very inferior drawing on Plate XVIII., fig. 3, of my Ichnology; but I have not the strength, dictating this as I do from a sick-bed, to go into a detailed comparison.

Arachnichnus dehiscens.

This track, as I described it in my Ichnology, connected with the singular appendage which gives it its name, was very obscure; but the type of it, as I now understand it, is very beautiful, and I have been tempted to have a fine double row

Localities, only as represented by specimens. Horse Race, Gill; Lily Pond; below the dam at Turner's Falls; north part of South Hadley; Northampton at the east foot of Mt. Tom, and at Bassett's Quarry, Easthampton; Wethersfield Cove, Connecticut; south-west part of Middletown, Connecticut.

BRONTOZOUM APPROXIMATUM. (Nov. Sp.)

Brontozoum giganteum, in part of the Ichnology.

[In the Cabinet, Nos. $\frac{2}{1}$, $\frac{12}{1}$, $\frac{15}{6}$, $\frac{15}{7}$, $\frac{15}{9}$, $\frac{15}{10}$, $\frac{15}{12}$, $\frac{20}{6}$, $\frac{29}{1}$, $\frac{33}{56}$, $\frac{34}{6}$, $\frac{38}{4}$, $\frac{43}{1}$, $\frac{43}{6}$, $\frac{44}{8}$, $\frac{44}{9}$, $\frac{45}{1}$, $\frac{52}{17}$, $\frac{53}{4}$, $\frac{53}{9}$.]

Divarication of the lateral toes, 50°; of the inner and middle toes, 30°; of the outer and middle toes 24°. Length of the middle toe, 9 inches; of the inner toe, 6 inches; of the outer toe, 6.5 inches; of the foot, 15 inches; of the step, 3 to 4 feet. Width of the toes, 1.75 to 2.12 inches; of the posterior part of the foot, 4.75 inches. Length of the claw, 1 inch. Distance between the tips of the lateral toes, 7.5 inches; between the tips of the outer and middle toes, 6.5 inches; between the inner and middle toes, 5.25 inches. Length of the middle toe beyond the lateral ones, 4 inches; of the first phalanx of the inner toe, 2.55 inches; of the second, 2.4 inches; of the first phalanx of the middle toe, 3.1 inches; of the second, 2.5 inches; of the third, 2.25 inches; of the proximal phalanx of the outer toe, 2.25 inches; of the second, 1.18 inches; of the third, 1 inch; of the fourth, 1.05 inches. Angle made by the axis of the animal's foot with the median line, and the distance of the centre of the heel from that line, about the same as B. giganteum. Width of the trackway, 14 inches. Measurements from No. $\frac{54}{10}$. In the slenderer proportions and the greater divarication of the toes, and at the same time the difference in size, will be found the chief differences between these two species.

Localities, as represented in the Cabinet, Horse Race, Gill; Ferry above Turner's Falls; Lily Pond; east foot of Mt. Tom, in Northampton.

of the hind and fore feet photographed and shown on Plate XVII., fig. 2, one-ninth of the natural size. (It is No. $\frac{51}{18}$, in the Cabinet.)

For the reason above suggested, I cannot formally compare this drawing with the description given in the Ichnology.

Supposed mistakes as to the number of Phalanges in some of the Lithichnozoa.

It is well known that the number of phalanges, and their order in the toes of living birds, enables the anatomist to distinguish them from other animals, with only a few exceptional cases. In four-toed birds, it is two in the inner toe, three in the second, four in the third, and five in the outer toe, and where there are only three toes, the numbers are the same as in the three outer toes of the four-toed birds. But since the penultimate and ungual phalanges would make only one impression, we should expect in the track that the numbers would be one less than above indicated. And such they seemed to be to every observer without exception in the three-toed pachydactylous Lithichnozoa, viz.: two in the inner, three in the middle, and four in the outer toe. This of course was regarded as the grand argument to prove them made by birds.

Sometime since, my suspicions were awakened that we had all been mistaken as to the true number of phalanges in these tracks, and when I went into an examination, I found it even so in respect to the outer toe. By looking at the drawings which myself and others have published of these tracks, it will be seen that what we have supposed the posterior phalanx in that toe, lies wholly behind the first phalanx of the inner and middle toes, and sometimes, also, a little out of the line of the other parts of the toe. Now by looking at the feet of the different species of birds, either in a cabinet or in drawings, we shall see that the posterior phalanges in the three toes lie nearly abreast of one another, unless it be the middle toe, where this phalanx is usually a little in advance.

This posterior impression behind the outer toe, was not, therefore, made by a phalanx, but probably by a process of the tarso-metatarsal bone. We accordingly sometimes find a similar posterior impression behind the inner toe, and indeed a third and smaller imprint of this sort shows itself sometimes, as on the sketch at page 78 of my Ichnology, and on Plate V., figs. 1 and 2 of the present paper.

These facts, I confess, very much unsettled my convictions that any of the Lithichnozoa were birds. And they were still farther shaken by the facts I have already detailed respecting that most anomalous animal, the Anomœpus. The trifid tracks of its hind feet had been mistaken by us all for those of birds. Indeed, the number of phalanges in the toes were found without much doubt to correspond with those of living birds, and also with those Lithichnozoa I had regarded as birds.

4

But the Anomœpus had been proved without question to be four-footed; and were we not forced to the conclusion that all the Lithichnozoa with similar trifid feet must be quadrupeds, either mammalian or reptilian?

Another development as to the Phalanges.

Probably I should ere long have come to this conclusion, had not another discovery awaited me. Among the new specimens purchased was one very beautiful row of thick-toed trifid tracks, such as we had been in the habit of supposing made by birds; but I have little doubt that they were those of an Anomœpus, though no marks of fore feet or tail are seen. I have named it as a new species (the *A. curvatus*,) of that genus, though differing but little from the A. intermedius already described. On looking at these tracks, I was surprised to find in the outer toe, *four very distinct phalangeal impressions besides the posterior imprint*, which I now regard as made by a heel and not a phalanx. Plate I., fig. 2, gives an exact outline of one of these tracks, and on examining the remarkable slab of Anomœpus intermedius already described, I found one proving that in some cases the outer toe had made four phalangeal impressions besides the heel bone, as may be seen in Plate I., fig. 1. So far as the Anomœpus is concerned, then, I feel sure that we have in its phalangeal impressions the normal number and order in the feet of living birds. I was at once led to inquire whether the same thing might not be true in respect to those thick-toed Lithichnozoa which I have regarded as birds. I have found proof enough to satisfy myself that it is so, and that the reason the fact has been overlooked is, that the penultimate and ultimate phalanges (omitting the ungual,) rarely made separate impressions. But I had frequently noticed that the length of the ultimate phalangeal impression on the outer toe (as a reference to the outlines of these tracks in the Ichnology will show,) was as long as, and sometimes longer than those which preceded it, whereas, so far as I have examined the osteology of birds' feet, the phalanges decrease in length towards the extremity. I think that generally two phalanges have been mistaken for one in this part of the toe.

If these are probable conclusions, they lead to important results. The first is, that if we strike off the posterior impression of the outer toe in the thick-toed bird tracks referred to, we shall still have the normal number of phalanges in the feet of living birds. But, secondly, the same thing is proved still more decidedly in regard to the Anomœpus, which is four-footed. Hence the conclusion follows that in the fossil foot-marks, birds cannot be distinguished from quadrupeds by the number of phalanges. This law of correlation among living animals would seem not to have been true with the fossil.

How far do the Protuberances on the Feet of Animals correspond with the Phalanges?

This subject could not but engage my attention in the progress of these investigations. But not finding it discussed by any anatomical author, and being prevented by feeble health and winter weather from access to any large collections of animals, I have been able to arrive at only unsatisfactory results. My examinations have been confined chiefly to the feet of birds, and the following facts have been obtained. The most important question under consideration is this: Is it the phalanges, or the articulations of the toes, that make the deepest impression on mud, or other plastic material trod upon? This will be determined by finding under which of these parts the protuberances are the most prominent. If under the phalanges the number in the toe will be one less than if under the articulations; that is, if we count as one of them, the articulation with the tarsal or metatarsal bone.

The protuberances on the foot of the turkey, both wild and tame, correspond neither with the phalanges, nor the articulations, but are more numerous than either. The same is true of the domestic hen. There is a general resemblance, however, in this respect between different individuals.

In the Botaurus lentiginosus, the protuberances seem to correspond with the articulations or joints.

In the coot, the wings along the toes expand most in the middle of the phalanges.

In the crow, the correspondence seems to be essentially with the articulations, judging from some tracks of this bird on clay, in the Cabinet.

But the Struthionidæ have feet more nearly resembling the tracks under consideration. And in the Rhea Americana or S. American ostrich, although these protuberances are tolerably distinct on the middle toe, yet the inner and outer toes do not show them. A large heel shows itself behind the middle toe.

These few examples show that there is great diversity among living birds in the matter under consideration. Sometimes the protuberances correspond to the articulations; sometimes to the phalanges, and sometimes to neither. But I have never found feet that would make such distinct and marked tracks, and with always the same number of rounded impressions as did the thick-toed Lithichnozoa, and I am still inclined to believe that such was the structure of their feet that their tracks would show the number of phalanges rather than of the articulations. It could not be the latter, if the views I have presented in this paper as to the posterior imprint in the outer toe be correct, for that impression is entirely behind the phalanges on all

the toes. I could wish, however, that I had time, strength, and opportunity to pursue this subject farther among existing species of animals.*

But though my researches have been unsatisfactory on the particular point above mooted, they seem to me to have settled another of much interest. I do find protuberances on the feet of birds, especially the tridactyle species, behind the phalanges, such as might well have left those impressions on the tracks which we have mistaken for the posterior phalanx. We are thus relieved from the necessity of supposing anything peculiar in the processes of the tarso-metatarsal bone in the fossil animals.

The Feathered Fossil of Solenhofen.

The recent discovery of a remarkable animal called by some *Griphosaurus*, and by others, Archæopteryx, in the famous lithographic quarries of Solenhofen in Bavaria, throws some light, I think, upon the thick-toed Lithichnozoa, while they reflect some light upon the feathered fossil—for it had feathers—yet some of the ablest Zoölogists pronounced it a reptile; others, however, as Professor Owen, of London, and Professor Dana, of New Haven, believed it to have a predominance of ornithic characters, so as to make it a bird.

Some important parts of the skeleton are wanting, as the head, neck, dorsal vertebræ, and sacrum, and the ribs are detached and scattered about.

The forearm consists of a radius and ulna, a metacarpal bone, and a few detached small fingers, also two small slender bones, with sharp claws, like those on the hind foot, and which may have been used for clinging, or as weapons of offence.

The lower right limb consists of femur, tibia, and tarso-metatarsus, to which one hind toe, and three fore toes are articulated, the phalanges being 1, 2, 3, and 4; though the last number is a little doubtful on account of the position of the outer toe. The toes are all armed with sharp claws.

The tail is six inches in length, and consists of twenty vertebræ, of narrow, elongated form, diminishing in size to the last. The feathers of the tail are attached in pairs to each vertebra, throughout its entire length.

Now between these characters and those of some of our Lithichnozoa, there are some remarkable analogies, or resemblances, so far as I can judge, and which I

* August 8th, 1863.—I have just met with the statement in an early edition of Buffon's Natural History, (Tome Huitiéme, p. 87,) that "the toes of frogs (*Grenouilles*,) are pointed without a lenticular pellet (*pelotte lenticulare*,) and ordinarily provided with a small tubercle under each articulation of the phalanges." This last fact so striking in the thick-toed Lithichnozoa, would seem to give them a strong batrachoid character; but in the number of feet, of toes and phalanges, there is nothing batrachian, but the bird type is very striking. Let all the facts however, be kept in mind, as they will lead to the truth at last.

would now indicate; at least such as have arrested my attention, with some of the inferences I draw from them. It is perhaps unexpected that they ally the Archæopteryx rather to the Anomœpus quadrupedal, than the biped tridactyles of my Ichnology.

1. In both we have on the hind foot, three front toes, articulated to a stout tarso-metatarsal, and not as in all animals except birds to a tarsus of several bones. This resemblance applies also to the biped thick-toed tridactyle Lithichnozoa, as well as to the Anomœpus; for they must all have had tarso-metatarsals below the tibia and fibula, though no impressions among the tracks indicate any such bone. But we have the most decisive evidence that these animals had only three toes; and where in existing nature do we find that number articulated with a tarso-metatarsus, (except a few cases in the Ruminantia and Solipedia?)

2. They both had the same number of phalanges in the three front toes, though a little doubt remains as to the outer toe of the fossil. The same number of phalanges existed in the biped Lithichnozoa, so far as we can judge by their tracks.

3. The posterior extremities of both, as far as the tarsal joint, correspond exactly with those of living birds; hence the tracks of the hind feet of Anomœpus as well as those of the biped Lithichnozoa under consideration, are pronounced at once on first seeing them to have been made by birds, and it is only when occasionally we see where the Anomœpus brought its fore feet to the ground, that we suspect it could have been four-footed.

4. Precisely how much correspondence there may be in the anterior extremities of the two animals, we cannot decide. The Archæopteryx is thought to have had but one metacarpal bone, and the fingers are so scattered that their number is not given; but two are described as slender, with long claws. The most perfect tracks of the fore foot of Anomœpus has five toes, all of which, except the hindmost, have claws, and probably that has also, but it is not visible on the track. The two hindmost toes have two phalanges, the third four, the fourth three, and the fifth two. The fingers are so arranged as to be fan-shaped, all pointing more or less outward, resembling an expanded wing. But they seem to be genuine fingers, and there is no appearance of feathers on any of the tracks of hind or fore feet. Plate II., fig. 1, shows an outline of the most perfect track of the fore foot yet found.

This certainly looks more like the fore foot of a lizard, and still more like that of some mammals, than the fore arm of a bird; and it is difficult to conceive how it could have been used as an organ of flight, though possibly it might have been employed for prehension. But on the other hand, we have conclusive evidence that it was not used for walking, except, perhaps, occasionally and imperfectly. The

right and left anterior feet that made the tracks, were placed almost invariably nearly abreast of each other, as if the animals were resting, and not in alternation as in walking. But of more than forty steps of Anomœpus intermedius shown on the remarkable slab (Plate XV., fig. 1,) described in this paper, the fore feet, show themselves only twice, and that where the animal rested. Indeed, we may safely assume that the principal object of the fore feet was not locomotion, and the same remark is applicable to other species, even the gigantic Otozoum. What other purpose in the economy of these animals could have been subserved by such a structure, except, perhaps, prehension, I will not attempt to decide. Yet the fact has awakened an inquiry in my mind, whether such a structure may not have existed in an animal whose predominant characteristics were those of a bird.

5. But there was a tail, and how shall we reconcile that with an ornithic character? It might have been impossible before the discovery of the fossil at Solenhofen. But that animal had a tail six inches long with twenty vertebræ; and yet the most eminent Zoölogists regard it as a bird. The characters of the tail in the Anomœpus are very peculiar; yet there are some curious resemblances between its markings on stone, and the tail of the Archæopteryx. The traces of the tail of the Anomœpus have three distinct phases. The largest species left a heart-shaped indentation, from two to three inches in diameter, which was repeated once in about ten inches.

The A. minor left an ovoid indentation, which was repeated every few inches. Would not such impressions be just what we might expect if this animal had a short blunt tail like the Archæopteryx? And does it not suggest one of the uses of such a tail, viz.: to furnish the animal with a sort of third hind foot to help sustain it, while it might use its fore feet perhaps for seizing upon objects above and around it?

The tail of the Anomœpus intermedius, although rarely leaving an impression, did sometimes drag along and make a narrow continuous trail. This would indicate greater length, and perhaps tenuity. But how much of attenuation and elongation might be consistent with an ornithic type, we have no means of knowing. Professor Dana speaks of "a posterior elongation of the body as connected profoundly with inferiority of grade in the different types of animal life," and says that "it is the very one of all abnormal features to be looked for in the early birds."

Upon the whole, the singular markings of the tail upon stone, with the exception perhaps of A. intermedius, do really suggest a curious coincidence between the caudal extremity of this genus, and that of the Archæopteryx.

Just as I had reached this point in my conclusions, a curious development awaited me. In examining some new specimens, a singular trail showed itself upon

one, which I had never before noticed, or if I had seen it, I had not connected it with the tracks, but considered it among those inexplicable markings, due perhaps to water and wind, which so frequently puzzle the student of Ichnology. But in this case a series of some six or seven rather flat and broad grooves, each, one to two-tenths of an inch wide, and the whole forming a trail an inch wide, (see Plate XVI., fig. 2, and No. $\frac{54}{2}$ in the Cabinet,) ran across the entire specimen, passing over one very distinct trifid, narrow-toed track, which is half an inch deep, and the grooves show themselves on opposite sides of the foot-mark, certainly two-thirds of its depth, appearing as if some flipper-like appendage had dragged behind the animal, capable of easily conforming itself to the irregularities of the surface. The fact that it made its marks deep into the track, shows that it was made subsequent to the track, and suggests at once the idea of a broad and singular tail. What a pity it is that there is only one track upon the specimen! But so far as I can judge, the tail runs in the direction in which the animal was moving.

In these conclusions I should have acquiesced with considerable confidence had I not found on examining our new specimens as well as others previously in the Cabinet, that we have quite a number with similar markings, and that the trails in these do not always follow the line of tracks but are sometimes on one side of it and sometimes on the other; now and then on both sides, and then crossing the line of track so as to seem to have no connection with them. In general, however, it seems as if some appendage to the posterior part of the animal had been thrown out on one side and the other, making sweeps occasionally so as to leave curved trails. The species of track with which they are most usually associated is the Anisopus gracilior, described in the first part of this paper. (See Nos. $\frac{45}{5}$, $\frac{45}{6}$, in the Cabinet.) In this species both hind and fore feet are almost always shown, and it is quite obvious that the flipper-like impressions have no connection with the feet.

They seem also rather large for the tail of so small an animal, whose feet are all less than an inch across. I have, hence, been sometimes inclined to believe that the trails were made by some animal swimming along near the bottom, and occasionally striking and grooving it with its flippers or fins. But my more mature conviction is that they are connected with the tracks. It needs a series of expensive drawings to make the facts fully understood without specimens.

6. But to return to the Anomœpus. Which character shall we now regard as predominating in its structure and movements, those of the bird, or those of the lizard, or mammal? It is difficult to avoid the conclusion that the ornithic characters are the most numerous and striking. It may after all have been a bird, of so low a grade, however, that even with its skeleton before him, the anatomist would hesitate where to place it, as in the case of the Archæopteryx.

7. This conclusion to which the facts and reasoning have conducted me, not without remaining doubts, would, not long since have appeared very absurd. But if it could be admitted, see what a relief it gives to difficulties. If the Anomœpus were a lizard or a marsupial, we must give up that firmly established law of correlation, which enables us to distinguish different classes of animals by the number and order of phalanges, but if it were a bird, the law can still be reckoned upon among the fossil as well as living animals. If a bird, we can see, also, how it was that it generally walked upon two feet, although it had another pair to be used perhaps for several purposes, but rarely for locomotion.

8. If we can presume that the Anomœpus was a bird, it lends strong confirmation to another still more important conclusion, which is that all the fourteen species of thick-toed bipeds which I have described in the Ichnology, and in this paper, were birds. In this case, if we can retain the law as to the phalanges, all the characters of the animals as made known by their tracks, belong to birds, with little variation from the existing bird type. They were bipeds unquestionably. Since they are the most abundant of the tracks, I have now seen thousands of them, and had fore feet existed, I am sure they would occasionally have left some trace of them, as is the case with every other species of Lithichnozoa. They had but three toes; at least if a fourth existed in any case, it must have been articulated so high as not to reach the ground. These three toes are articulated to a tarso-metatarsus, as is the case with nearly all tridactyle animals. They had the same number of phalanges as birds. The impressions left by the cushion beneath those processes of the tarso-metatarsus, which form the heel, correspond to those which living birds would make, so far as I have examined, not to those of any other class of animals, though my examinations on this point have been few. The claws and papillæ agree essentially with those of birds. Finally, the great length of stride in some cases, and the position of the tracks nearly on a right line indicate the long legs of wading birds, and not any other kind of animals.

Most of these arguments are good for the ornithic origin of these tracks, whatever opinion we may entertain as to the Anomœpus. The only difference is, that if we regard it as a reptile, the argument from the number of phalanges must be given up; if as a bird, that strong evidence is retained. But even without this, I cannot hesitate to reckon the biped thick-toed Lithichnozoa as birds; for I see no characters in their track that ally them to any other animals. I must consider them not only as birds, but as forming a quite perfect type of birds for sandstone days The analogies taught us by Paleontology (see Professor Dana's appended letter,)

would lead us to expect also in the same period, a lower group of birds, and those may have been the Archæopteryx, and perhaps the Anomœpus, with some other genera of Lithichnozoa which we might name.

How then could I avoid the conclusion that these animals were birds? Doubtless with some peculiarities of structure, bringing them into the "*comprehensive types*" of Dana, but still decidedly birds. When I began this paper, and ascertained that we had probably made a mistake as to the number of phalanges, I felt as if this opinion which I have always maintained was becoming doubtful. But new examinations brought new facts to light, and the history of the Solenhofen fossil added others, until it appears to me, we may now with more confidence than ever, maintain the ornithic character of these animals. It is certainly gratifying even to seem to touch soundings after having been so much tossed on the sea of difficulty, and I cannot but hope that subsequent researches will show that we have not cast anchor merely in quicksand.

Professor Dana's Views.

Having occasion, while engaged in the investigations detailed in the preceding paper, to write a letter on business to Professor J. D. Dana, I mentioned some of the results to which my mind was coming. His reply contains too much good reasoning and important suggestions to be lost, and I venture, without asking his leave, but trusting he will excuse me, to annex his remarks to this paper.

"New Haven, February 7, 1863.

"My Dear Sir:—Your new results from recent researches among the tracks of the Connecticut Valley, are of great interest, and I should be glad to put your conclusions, when you are ready with them, in the Journal. I am satisfied that we cannot infer the form and character of the earliest birds from those of the present day. The early type was evidently one of the mixed types (comprehensive, as I have called them,) which diverged widely from the normal type—just in fact, as the Ganoids diverge from the Ctenoids and the Cycloids—the marsupials from ordinary mammals, and Amphibians (or Batrachians) from true Reptiles. You know that in the class of Mammals the marsupials are *semi-oviparous*, or intermediate between the true viviparous Mammals and the oviparous birds and reptiles. So again the Amphibians are intermediate between true reptiles and fishes, having gills when young, like fishes, etc. Now by the recent discovery of the feathered fossil of Solenhofen, we have a corresponding inferior division of birds intermediate between birds and reptiles. Thus each class has its great typical group

and its inferior abnormal group, related to the class next below. This being so, wide divergencies of form in the abnormal group are to be looked for.

"There is another principle bearing on this subject—*the remarkable harmony among the types of any era through the past ages.* Thus the coal-plants are made up mainly (1) of the highest Cryptogams, that is, the *Acrogens,* of which the Fern is the typical group, (2) the lowest Phænogams, the Conifers, and (3) intermediate (or comprehensive) types in each class, Lepidodendra of the Lycopodium tribe, a type coniferous in habit, and Sigillariæ of the Phænogams, also intermediate between Conifers (in the Gymnosperms,) and the Lepidodendra. By such an assemblage, the flora was rendered remarkably harmonious. Had the progress of life consisted in an advance of Cryptogams to mosses, along with the introduction of Conifers, it would have been far otherwise.

"Again, (1) the Reptilian fishes (Ganoids,) (2) Amphibians, Reptilians and (3) fish-like higher Reptilians (Marsh's Eosaurus,) made up a harmonious assemblage of carboniferous *animal* life. Again, the semi-oviparous Mammals (Marsupials,) and oviparous Reptiles, &c., were in harmony with one another; and if true non-marsupial Insectivores appeared also, it was still in harmony; for the Marsupials were mainly Insectivores; moreover, the former were prophetic of the higher development of the Mammalian class. Now, if, along with the semi-oviparous Mammals and swimming, crawling, and flying Reptiles, there were Reptilian birds, waders and others, the harmony would only be more complete. The presence of the same number of phalanges in birds and reptiles would be not at all improbable—certainly no basis for an argument against the birds."

In another business letter of February 14, I find the following:—

"The strongest arguments for the ornithic character of the feathered fossils, are—

"1. *That the animal had feathers;* for the idea that they were not true feathers, is a mere supposition, without any facts to sustain it:

"2. That the *expanse of the wing was made by feathers on a short arm,* and not as in the Pterodactyle by an expanse of the skin supported by an elongated finger. The structure of the foot in the Pterodactyle also shows that the animal had no close relation to the Birds. The world will have finally to settle down into the belief that there were Reptilian birds in ancient times, as well as Ichthyoid Reptiles and Oöticoid Mammals. This is my strong persuasion."

POSTSCRIPT.

Still more recently, not in fact till this paper was completed, another specimen among the new tracks, arrested my attention, containing some curious markings, leading us even still farther than the text, in conjectures, as to the avian character, even of some of the ancient quadrupeds. I found a new species of that most remarkable genus, the Plesiornis, showing certain groovings and indentations, which may give us some insight into the character of the tail of the animal. This genus, as described in my Ichnology, where two, and perhaps three species are given, exhibits both a hind and fore tridactyle foot, exactly resembling that of a bird, and in fact showing the same number of phalangeal impressions, yet the fore foot is always the smallest; but it was a long time before I could be persuaded that these tracks were not made by two species of birds, walking on parallel lines. But I cannot doubt that they are true tridactyle quadrupeds, though the toes of the most characteristic species (P. pilulatus,) are terminated by pellets instead of claws. The new species, which I call Plesiornis mirabilis, has claws, and the tracks exactly resemble a large species of Grallator. It was the attendant groovings and markings which arrested my attention, and I have attempted to give an idea of them, of the natural size, by adding Plate XX.

The technical description which follows, will, I hope, make the facts more intelligible.

37. Plesiornis mirabilis.

[In the Cabinet No. $\frac{51}{16}$.]

Hind Foot.—Divarication of the lateral toes, 35° to 40°. Length of the foot, 6 to $6\frac{5}{10}$ inches. Width of the foot, $3\frac{1}{2}$ to 4 inches. Length of the step as measured by the hind foot, $12\frac{1}{2}$ inches. Claws distinct, but not the phalangeal impressions.

Fore Foot.—Divarication of the lateral toes, between 80° and 90°. Length of the foot, $3\frac{1}{2}$ inches. Width of the foot, 3 inches. Length of the step as measured by the fore foot, 12 to 14 inches. Claws indistinct. Hind and fore feet sometimes in contact, sometimes almost three inches apart, but nearly abreast. Several very distinct grooves making a train $3\frac{1}{2}$ inches wide, following in the line of the tracks, varying in width from a mere line up to half an inch, not exactly parallel, and some of them broken off in one or two places. A little to the left hand side of the

grooves are three distinct cases of rounded impressions, from a quarter to half an inch in diameter, as if the blunt ends of a bundle of sticks of different sizes had been impressed on the mud. Behind two sets of these impressions, grooves from $\frac{1}{2}$ inch to $1\frac{1}{4}$ inches wide, extend from three to four inches. The whole appears as if the bundle of cylinders had dragged along the surface, until at length the animal rested on their extremities, then lifting them up, had moved forward and made other impressions. This may be only conjecture, but such is the appearance.

On the left hand groove, behind the foremost track, for six inches, the sides present so strong a resemblance to the impression of a feather, that I have had it sketched. For although I cannot persuade myself that it is such, it certainly bears a stronger resemblance to it than anything I have seen elsewhere. And I know not why, if the animal had, for instance, a tail with feathers, we may not hope to find their impressions on some delicate specimens.

Now have we not in these facts rather strong presumptive evidence of the passage of an animal which had a tail of a peculiar character, viz.: with several digitations at the extremity, and capable of being used as a foot in certain cases, so as to leave successive steps, yet usually dragging along so as to form grooves? The stone has on it several other tracks not given in the drawing, and some other obscure markings which if fully understood, might lead to a different interpretation. But I have selected what seems to form a consistent whole. If correct, we are led to conclusions, analogous indeed to those in the text, but carrying us a good deal farther in the same direction, so that we are led almost to conclude that some of the decided quadrupeds among the Lithichnozoa, were birds. The argument stands as follows:—

1. The Plesiornis was undoubtedly a quadruped. The P. quadrupes differs from the P. mirabilis only in the greater divarication of the toes, the length of the foot, and the greater disparity between the hind and fore feet. The P. pilulatus, is a much more slender species, with rounded extremities instead of claws. The P. æqualipes I pass over, because a little uncertain. But the disparity of size between the hind and fore feet, in all the species, while yet a large and a small track are always in pairs, and nearly abreast, makes it almost certain that all the species were quadrupeds. (See the drawings in my Ichnology.)

2. The feet, in their general forms, their trifid digitation, their claws, with one exception, and the number of phalanges, so far as has been ascertained, correspond precisely with those of birds.

3. The supposed existence of a tail in the P. mirabilis, is the only fact going against the avian character of the foot-marks, and the Solenhofen fossil shows that this is not inconsistent with such a character.

I would not have it understood, however, that I adopt the opinion that any of these ancient quadrupeds which used their fore feet for locomotion, were really birds. I could believe that a bird might have four feet; but I have imagined that in such a case the anterior feet would be very peculiar, and not ordinarily used for locomotion. But the very decided ornithic type of everything about the tracks of the Plesiornis, may well raise the question whether an animal might not be a real quadruped moving on four feet, with a tail, and yet a real bird. However, most naturalists, probably, will take the ground that such an animal was rather an ornithoid Batrachian, or a lizard, or marsupial. And this perhaps would be the safest conclusion. Yet the facts are certainly very remarkable; and should lead us to keep our eyes open to all reasonable suggestions, and certainly to admit that the bird-type in sandstone days may have exhibited forms very different from the perfect bird-type of the present day.

AMHERST, July 1*st*, 1863.

SECOND POSTSCRIPT.

DECEMBER 25*th*, 1863.

Even up to the present date, when I am able only occasionally to catch a passing glance at the Cabinet, new facts respecting Tail Traces, continue to arrest my attention. Of No. $\frac{7}{1}$ I gave some account in the Ichnology, but not a Plate. It shows a blunt impression of a tail two inches across; but the other species, A. minor, exhibits an elongated trace, which may however, have been made by a stout, blunt tail, dragging along, and occasionally striking the mud. I have found something similar on No. $\frac{7}{1}$, and have thought it desirable on this account to give a photograph of the slab in Plate XIX.* This is the specimen described on page 57 of the Ichnology. The fore feet are wanting, but the tail impression is quite distinct, and I think it is repeated near the right hand foot, after dragging several inches. I doubt not that similar markings will reward the researches of other explorers in the Cabinet, of which I must now take a final leave.

* A photograph of the same slab is given in Deane's "Ichnographs," Plate XXXI.—C. H. H.

APPENDIX. [A.]

BONES OF MEGADACTYLUS POLYZELUS.

By Edward Hitchcock, M. D.

Since the description of the bones on the 187th page of the Report on Ichnology was made, they have been shown to Professor Owen, of the British Museum, London, and a few new points have been made out, by more thoroughly exposing them with a graver.

Professor Owen very kindly gave his attention to the fossils during the limited time I was in London, and made his determinations concerning them, though "subject to correction." They are regarded by him as belonging to a "Saurian Reptile with an unusually thin and compact wall of bone in the limb bones, which, however, might have been occupied by unossified cartilage, as in the young crocodile and turtle; but if they were filled with oil or light marrow, it would point to a course of development towards Pterodactyles or Birds. This phrase is purely hypothetical, and I mean to express no more than a degree of resemblance, supposing marrow and not gristle to have filled the large cavities."

The most important characteristics of these fossils so far as determining the genus is concerned, are in the bones of the right foot, which are tolerably well preserved, and a drawing of which — of the natural size, in Plate IX., fig. 6, — has been made by my sister, Miss Emily Hitchcock. From this drawing it will be seen that the prominent character of the foot is in the robustness of the pollex. Hence Professor Owen suggests the generic name Megadactylus. The only other terminal phalanx of this extremity, is found on the fourth toe. And it might possibly seem that there were no claws on any toe but the first one, were it not that among the fragments of the skeleton, another claw is preserved which is only about one-fourth the size of the one figured on the Plate.

When the specimens were shown to Professors OWEN and WYMAN, it was thought that the foot was only four-toed, as a portion of the phalanges was covered by fragments of the rock. But close and careful work with the graver have uncovered the first and third phalanges of the fourth toe, seeming to show that the single phalanx on the right must have belonged to a fifth toe. Its greater size, also, shows that it could not have belonged to the fourth finger.

In addition to the three phalanges of the fourth toe, a small bony knob was found, seeming to represent a fourth phalanx, or rudimentary claw. This, however, is so small, and the fragments of bone are so numerous throughout the rock, that it is possible it is only a bony fragment accidentally located in the position of a phalanx.

For a specific name to this individual, I propose the name POLYZELUS, "much sought for," in allusion to the fact that for so many years other remains than simply tracks of the former inhabitants of the Connecticut Valley, have been eagerly and anxiously sought for, and that now we have the much coveted bones.

APPENDIX [B.]

DESCRIPTIVE CATALOGUE

OF THE

SPECIMENS IN THE HITCHCOCK ICHNOLOGICAL CABINET

OF

AMHERST COLLEGE.

PREPARED BY

C. H. HITCHCOCK.

DESCRIPTIVE CATALOGUE.

The specimens in the Hitchcock Ichnological Cabinet, are in the form of thin slabs of stone, so distributed over various tables, cases, and walls, as to secure the best positions for display, in the lower rooms of the Appleton Cabinet building. Each table, case, or wall is numbered; and the slabs covering or resting upon the several tables, etc., are numbered separately, there being a set of numbers for every table, etc., in the room. These two sets of numbers are combined into a fraction, the number of the table or case constituting the numerator and the number of the slab the denominator of the fraction. Every slab will be found with the printed fraction upon it corresponding to its place in the Catalogue. Sometimes the number is also engraved or painted upon the slab. For convenience in making out the descriptions in the Catalogue, we will use figures for the numbers of the tables, without expressing the whole fraction; but references to specimens upon other tables will always be given in full as entire fractions.

The following will be the order of description: 1. Number of the specimen. 2. Kind of stone. 3. Size. 4. Names and peculiar features of the ichnites. 5. Notice of any other objects of interest upon the slabs. 6. History of the slab or the date of its entrance into the Cabinet. 7. Locality. 8. References to places in the "Ichnology of Massachusetts," or the "Supplement," where the specimen is especially noticed or figured. For the sake of brevity, the signs commonly used to designate degrees and minutes, will be employed to denote feet and inches; and bare figures either for the dimensions or dates in the history of the specimen will be given in their assigned order, without description.

DESCRIPTION OF THE SLABS.

Wall No. 1.

The specimens upon the east wall of the large room belong to the first division.

1. A slab of reddish sandstone, 8° 4′ × 5° 4′. It contains 36 depressed tracks of the following species: Anomœpus major — the most remarkable consisting of the impressions of all four feet, two heels and a caudal mark — Brontozoum validum, B. Sillimanium, Amblonyx giganteus and A. Lyellianus. Is covered by marks of rain and vegetable (?) fragments. Procured at Marsh's auction in Greenfield, in 1853. From Field's Orchard, Turner's Falls, Gill. Noticed upon pages 57, 71 and 72, and figured upon Plate XXXVIII., fig. 2, of the Ichnology. Nos. 1 and 7 of this wall furnish the type of the species Anomœpus major.

2. A slab of reddish sandstone, 6° 3′ × 2° 7′, showing raised tracks of Brontozoum validum and Amblonyx Lyellianus, with rain-marks and vegetable (?) fragments. Procured at Marsh's auction. Dug up at Field's Orchard, Gill.

3. Micaceous shale, 5° 6′ × 7° 9′. Shows depressed tracks of Anisopus Deweyanus, Brontozoum divaricatum, B. Sillimanium, Grallator cuneatus, Gigantitherium minus, Hyphepus Fieldi, Apatichnus circumagens (a long row,) and Saltator caudatus. Surface covered by delicate rain-marks, and what resemble *toe-marks* of Brontozoum, etc. H. Fieldi very distinct. 1856. From the Lily Pond quarry on Field's farm, Turner's Falls. Figured, Plate XLII., fig. 2, of Ichnology, and noticed upon pages 61, 95, 97, and 100.

4. Micaceous sandstone, 4° 5′ × 2° 4′. Shows three impressions of Tridentipes insignis made upon ripple-marks. Fragment of the stipe of a fern. Obtained before 1842. From Marsh's quarry, south-west part of Montague. Noticed upon page 91, and figured upon Plate XLVII., fig. 2, of Ichnology.

5. Hard, irregular sandstone, 2° 10′ × 3° 6′. Shows tracks in relief, of Brontozoum Sillimanium, B. exsertum and Grallator cuneatus. From west bank of Connecticut River, below Smith's Ferry in Northampton, 1855.

6. Slab same as No. 5, 2° 5′ × 3° 8′, showing tracks in relief of Brontozoum exsertum. Same locality and history as No. 5.

7. Slab of trapezoidal shape, 9° 2′ × 7° 2′. Very fine impressions of the hind feet, heels, and tail of Anomœpus major. 1858. From Lily Pond quarry. Noticed upon page 57 of Ichnology, page 37 of Supplement, and photographed in Plate XIX. of Supplement.

Total number of tracks on Wall No. 1, 125.

Table No. 2.

Slabs upon elevated desk-like table by the south-east windows of the large room.

1. Flagstone, 4° 8′ × 5°, showing impressions of Brontozoum giganteum, B. approximatum, B. validum, and a variety of fragments of the stipes of the Clathropteris. 1855. From below Smith's Ferry, Northampton.

2. Flagstone, 4° 11′ × 3° 6′. Rows of Brontozoum validum. B. exsertum, B. Sillimanium (?), with fern stipes and ripple-marks. 1853 or 1854. Below Smith's Ferry.

3. Flagstone, 7° 3′ × 4° 11′. Tracks in relief of Brontozoum giganteum, B. validum and B. exsertum. Ripple-marks and shrinkage cracks. 1853 or 1854. Near Smith's Ferry.

4. Flagstone, 6° × 4° 6′. Impressions of Brontozoum giganteum with shrinkage cracks. 1853 or 1854. Near Smith's Ferry.

5. Micaceous sandstone, 5° 6′ × 3° 3′. One row of impressions of Brontozoum giganteum, and another of B. Sillimanium. 1854. Horse Race, Gill.

6. Flagging stone, 4° 2′ × 2°. Shows tracks in relief, remarkably distinct, of Brontozoum validum and B. exsertum. Some of these ichnites, the type of the old species B. expansum, which are with difficulty referred to any species in the existing classification. Slab used as a flagging stone at Turner's Falls, previous to 1848. Figured in Final Report, Geology of Massachusetts, Plate XLVIII., fig. 50.

7. Tough, thick slab of hard slightly reddish sandstone, 8° × 4°. Impressions of Brontozoum giganteum, upon uneven surface. 1855. Below Smith's Ferry.

8. Slab, 16′ × 13′, of ripple-marks. South Hadley (?). No. $\frac{22}{4}$ of Ichnology.

9. Slab, 19′ × 13′, of ripple-marks. South Hadley. No. $\frac{22}{17}$ of Ichnology.

10. Gray shale, 15′ × 12′, showing impressions of rain-drops. From Turner's Falls, below the dam. No. $\frac{23}{4}$ of Ichnology.

11. Shale with ripple-marks. South Hadley. No. $\frac{23}{7}$ of Ichnology.

Total number of tracks on Table No. 2, 91.

Table No. 3.

Table next platform, adjacent to No. 1.

1. Large slab, 30° × 4° 3′, made up of three separate slabs cemented together. The stone is broken up into numerous wedge-shaped joints. The layer of red mud, one-fourth of an inch above this layer, upon which the animals trod, could not be preserved. The slab was procured on account of a row of the depressed tracks of Otozoum Moodii, eleven in number. Other impressions are those of Anisopus Deweyanus, Brontozoum Sillimanium, Grallator formosus (type of species) and G. cursorius. 66 tracks in all. From Moody Corner, South Hadley. 1854. The original of Plate I. of Ichnology, designed for Frontispiece, and copied upon the salver of a silver service presented to Dr. Hitchcock by the Faculty and students of Amherst College in 1859. Figured also in Plate XXXIII., fig. 4, and mentioned on page 124.

Table No. 4.

1. Slab of coarse reddish sandstone, the counterpart of $\frac{3}{1}$. The western portion, 10° 8′ × 2° 10′, not naturally connected with the other part, 13° 4′ × 4°. The former was obtained by Pliny Moody of South Hadley, near his house in 1847, and subsequently presented by him to the Cabinet. The other part of the slab was removed from above No. $\frac{3}{1}$. Tracks the same as on $\frac{3}{1}$, except Grallator formosus is wanting. Those of G. cursorius are specially important as showing the animal producing them to have been a biped and not a quadruped. Slab covered with rain-marks. Older slab described in Amer. Journ. Sci. N. S. Vol. IV., p. 46; Trans. Amer. Acad. Arts and Sciences in 1849, and page 124 of Ichnology. Figured Plate XXXIII., fig. 5 of Ichnology. Newer slab the same references in the latter volume.

2. Micaceous sandstone, showing a single raised track of the Otozoum Moodii, from Turner's Falls. About 1855.

3. Micaceous sandstone with single impression of Otozoum Moodii, showing the marks of a web beyond the toes. Same locality as No. 2.

4. Same as No. 3. Page 126, and Plate XLVI., fig. 2 of Ichnology.

5. Same as No. 3. Single raised track, imperfect, and probably belonging to a smaller species.

6. Hard, gray shale, 1° 6′ × 8′. One track of Brontozoum exsertum or B. Sillimanium from Chicopee Falls. Before 1849. No. $\frac{22}{13}$ of Ichnology.

7. Slab, 2° 3′ × 9′. Two tracks in relief of Anomœpus minor, and a multitude of large rain-marks. No. $\frac{22}{5}$ of Ichnology.

Total number of tracks on this Table, 133.

Table No. 5.

1. Slab, 1° 7′ × 2° 1′ of sandstone. Single raised track of Otozoum Moodii with recurved "thumb," also one of Brontozoum Sillimanium. Broken and poorly mended. Moody quarry, South Hadley. 1854. Plate LIX., fig. 1 of Ichnology.

2. Slab of hard schistose sandstone, 2° 3′ × 1° 9′, like No. 4. Tracks in relief of Brontozoum exsertum and B. validum, with stipe of fern. From below Smith's Ferry. 1854.

3. Slab, 2° 5′ × 2°, showing depressed tracks of Brontozoum divaricatum, B. Sillimanium, B. validum, with delicate ripple-marks. Horse Race, Gill.

4. Hard schistose slab, 2° 6′ × 2°, exhibiting impressions of Brontozoum exsertum. From below Smith's Ferry. 1854.

5. Hard, schistose slab, 3° × 2°, with Brontozoum validum and B. exsertum in relief. 1854. Below Smith's Ferry.

6. Same as No. 5, 2° 8′ × 3° 10′.

7. Same as No. 5, 3° × 2°.

8. Slab, 3° 6′ × 3° 3′. Curved rows of impressions of Anomœpus curvatus, with a tail-trace. Shrinkage cracks and ripple-marks. Counterpart of No. $\frac{53}{7}$. 1858. Lily Pond quarry, Turner's Falls. Page 100, Plate XLVI., fig. 4 of Ichnology.

9. Hard schistose slab, 4° × 2° 6′. Tracks in relief of Brontozoum exsertum and Grallator cuneatus. Below Smith's Ferry. 1854. Ichnology, Plate XXXIX., fig. 4.

10. Gray micaceous flagging stone somewhat worn by use, 4° × 3°. Shows rows of Tridentipes insignis in relief. 1840. Below Smith's Ferry. Figured in Final Report Geol. Mass., Plate XLVIII., fig. 64.

11. Same as No. 10, showing in addition, rows of Platypterna varica and several conjectural coprolites. 4° × 4°. Page 91, Plate XLV., fig. 3 of Ichnology.

12. Same as No. 4, 2° 6′ × 2° 3′. Brontozoum exsertum and B. validum in relief.

13. Sandstone, 15′ × 12′, showing a single raised track of Otozoum Moodii. 1855. Moody quarry, South Hadley.

14. Coarse sandstone, slightly reddish. Shows in relief, both hind and fore feet of Otozoum Moodii, and tracks of Brontozoum Sillimanium. An unique and typical specimen for the Otozoum. 1855. Moody quarry, South Hadley. Pages 124–126, 183, Plate XLVI., fig. 5 of Ichnology.

Total number of tracks on this Table, 139.

Table No. 6.

1. Large, thick slab, placed upon edge, 6° 3′ × 5° 8′. On the east face are rows of Tridentipes uncus, Tarsodactylus caudatus, Brontozoum divaricatum, Orthodactylus floriferus, Chelonoides incedens, Saltator caudatus, Exocampe ornata, with obscure tracks of an unknown quadruped, "mud-holes" and unknown plant. On west side of slab, row of Platypterna varica, trail of bisulcate annelid and shrinkage cracks. 1855. From Lily Pond quarry, Turner's Falls. Figured in part, in Ichnology, Plate XLVI., fig. 1, Plate XLV., fig. 2.

2. Slab, 3° 3′ × 1° 6′, of hard argillaceous sandstone, showing many pebbles scattered over the surface. Row of Platypterna recta, (type of the species,) with transverse ripple-marks. 1854. From the south side at Turner's Falls. Page 85, Plate XLVII., fig. 3 of Ichnology.

3. Fine micaceous sandstone, 1° 11′ × 1° 6′. Tracks in relief of Otozoum Moodii (second species,) (?) Brontozoum exsertum, and two of Apatichnus circumagens. 1854. Ferry at Turner's Falls. Page 69, Plate XLVI., fig. 3 of Ichnology.

4. Red sandstone 2° 1′ × 1°, with row of impressions of Selenichnus breviusculus, and many rain-marks. Lily Pond.

5. Single track of Brontozoum exsertum, 12′ × 8′. From Ferry at Turner's Falls.

6. No. $\frac{22}{6}$ of Ichnology. Slab, 2° 2′ × 1° 4′, with single impressions of Brontozoum tuberatum and Amblonyx Lyellianus, and many rain-marks. Turner's Falls, Field's Orchard.

7. Reddish sandstone, 15′ × 12′, with marks of large rain-drops in relief. Turner's Falls.

8. Reddish shale, 1° 9′ × 1° 3′, showing thirteen pedal and caudal impressions of Plectropterna gracilis, and single ones of Brontozoum Sillimanium, Grallator cursorius and G. cuneatus (?). Turner's Falls.

Total number of tracks on this Table, 122.

Table No. 7.

1. Large slab of sandstone, 10° 3′ × 2° 3′. Contains three tracks of Brontozoum giganteum in relief — in a row — the largest in a row of this species in the Cabinet. Covered with stipes of ferns. 1842, or earlier. From below Smith's Ferry. Page 64, Plate XXXIII., fig. 2 of Ichnology.

Table No. 8.

1. Large slab running across from the platform to the south wall, 22° × 2° 5′. Micaceous sandstone, showing a row of seven tracks of the Brontozoum giganteum (?). If not B. approximatum, a small individual of B. giganteum. One of the most impressive slabs in the Cabinet. In two parts, one of them somewhat broken. Before 1842, from below Smith's Ferry. Page 64, Plate XXXIII., fig. 1 of Ichnology.

2, 3. Slabs of fine red sandstone, covered with nests of Batrachoides nidificans. 1855. Near South Hadley Falls. Page 123 of Ichnology.

Table No. 9.

1, 2, 3, 4, 5. Slabs of red sandstone, containing Batrachoides nidificans. Near South Hadley Falls. 1855. Page 123 of Ichnology.

6, 7. Slabs, 3° 6′ × 2° 8′, and 2° × 1° 5′, showing Batrachoides nidificans. South Hadley Falls. 1855.

8. Red shale, 2° 5′ × 2°, showing on front side seven tracks of Brontozoum validum; behind, eight tracks of the same in relief, not corresponding to those in front. Two miles north of the village of South Hadley on a hill. About 1849.

9. Large slab of reddish shale, 7° 1′ × 2° 3′, standing upon its edge, lengthwise of the table, showing three remarkable tracks of Gigantitherium caudatum with tail-trace; also two or three rows of Saltator caudatus, and a single track of Tridentipes. Few shrinkage cracks. Lily Pond, Turner's Falls. 1855. Presented by Roswell Field, Esq. Page 94, Plate XLIV., fig. 4 of Ichnology, both of this and No. 10.

10. A larger slab than No. 9, 12° 3′ × 2° 6′, the continuation of No. 9, with perhaps two or three feet gone between them. Shows in front, four tracks with tail-trace of Gigantitherium caudatum, a row of seven tracks of Tridentipes uncus, one of four tracks of Platypterna varica, one of four tracks of Chelonoides incedens, a second row of five tracks of Tridentipes uncus, one track of Brontozoum Sillimanium, and shrinkage cracks. On back side, five tracks of Brontozoa.

One of B. giganteum looks like a depressed track, when in fact it is in relief. The apparent depression results from the great irregularity of the surface. Described in Amer. Jour. Sci. N. S., Vol. XXI., p. 97. Ichnology, Plate XLIV., fig. 4, LVII., fig. 7.

11. Large thin slab of gray shale, resting edgewise upon Nos. 9 and 10, 7° 4′ × 2° 4′. On one side in relief, there is a row of three tracks of Brontozoum minusculum, two tracks of B. exsertum, four of Grallator cuneatus, and portions of several other similar tracks.

On the other side (facing the door,) may be seen a row of three impressions of Brontozoum giganteum, a single one of the same, (two toes,) most of a track of B. divaricatum, two rows and several single tracks of Grallator cuneatus, a row of four tracks of the hind feet of Apatichnus circumagens, delicate impressions of rain-drops, and a multitude of those triangular *dents*, which are of obvious organic origin. The upper side shows that tracks may interfere with one another without obliterating either of them. 1855. Lily Pond.

12. Slab of micaceous gray sandstone, 3° × 1° 5′, showing two rows of tracks in relief of Argozoum pari-digitatum. Turner's Falls.

13. Slab, 2° × 1° 10′, showing two rows of Anisopus gracilis, a large number of tracks of Grammepus erismatus, and an Annelid (?) trail. About 100 tracks in all. Turner's Falls.

14. Slab of reddish flagging stone from Middlefield, Connecticut, 5° × 3° 4′. Shows in relief 48 tracks of Brontozoum Sillimanium, six of B. exsertum, three trails of Cunicularius retrahens, shrinkage cracks, and one curious ring of unknown nature. "The gem of the Cabinet because everything is so distinct." E. H. History given in Ichnology, page 68. See Plate LX. fig. 1. 1856.

15. Slab, 3° 8′ × 1° 4′, with two rows of two and six impressions of feet of Platypterna varica (?) with one of a smaller species. Stride more irregular than common. Turner's Falls.

Total number of tracks on this Table, not including Batrachoides, 388.

TABLE No. 10.

1. Large slab, 10° × 3° 3′, of gray micaceous sandstone from below Smith's Ferry, Northampton. Contains one depressed row of three tracks of Brontozoum minusculum, rows of B. validum, B. exsertum, Grallator formosus, and G. cuneatus; in all about fifty tracks. 1854. Sketched in outline, Plate XXXIII., fig. 3 of Ichnology, but some of the tracks omitted.

2. Slab of hard gray sandstone, 3° 6′ × 2° 3′, from the quarries near the Hudson River in New York, of the Hamilton Group, Devonian. Shows 26 tracks or 52 impressions of the Harpagopus Hudsonius. Type of the species. Taken by E. H., from the sidewalk in Greenwich Street, New York, before 1849. See Ichnology, page 147, and Plate XLIX., fig. 6.

3. Gray shale, 3° × 1° 8′, containing at least fifty tracks of Anisopus gracilis, with ripple-marks. Horse Race, Gill. 1856.

4, 5. Slabs of reddish micaceous sandstone, a little more than two feet square, split apart so as to show both raised and depressed tracks. Track of Anticheiropus pilulatus, the largest of all the ichnites. Dug up early in the history of the science, but until the publication of the Supplement, regarded as a *lusus*. See the Supplement, page 10, and Plate IX., figs. 1 and 2. From Marsh's quarry, S. W. Montague. About 1842.

6. Slab of reddish shale, 10° 6′ × 3° 9′. On the front or west side, one row of three tracks of Brontozoum exsertum, one track of B. tuberatum, other Brontozoa, two rows of Grallator cursorius, several rows of Platypterna varica, Anomœpus curvatus (?), two rows of Sphærapus magnus, and a long branching sea-weed (?).

On back side (or relief,) one track of Brontozoum validum, a row of Platypterna varica and two delicate trails of Bisulcus undulatus, the type of the species. Supplement, Plate III., fig. 5. In all, 85 tracks. Field's Orchard, Gill. 1855.

7. Fragment, 3° × 2° 4′, broken off from No. 6. Shows a row of fine tracks of an Orthodactylus, Unisulcus Marshi, numerous twigs of a coniferous plant, and an abundance of rain-marks. The same may be seen in relief upon the back side of No. 6, whence this was split off.

Total number of tracks on this Table, 213.

Table No. 11.

1. Gray micaceous sandstone, 6° 9′ × 2° 5′, with a row of ten tracks of Platypterna varica. Taken from the sidewalk in front of house of Franklin Ripley, Esq., of Greenfield, in 1853. From Turner's Falls. Ichnology, Plate XLVII., fig. 4, page 85.

2. Dark gray sandstone, 2° 4′ × 1° 2′, showing two tracks of Tridentipes uncus. Ferry at Turner's Falls. Before 1848.

3. Same as No. 2, but showing the tracks in relief.

4, 5. Small thick slabs, near 2° long, showing both the depressed and raised tracks of Platypterna varica. Ferry at Turner's Falls. Probably the type of the species.

Total number of tracks on this Table, 22.

Table No. 12.

1. Slab of gray sandstone, 3° 3′ × 2° 3′, with two depressed tracks of Brontozoum approximatum, two hind tracks of Palamopus Clarki, and probably a track of the fore foot between them. Also tracks of B. validum, B. exsertum and B. tuberatum (?). Obtained by Prof. W. S. Clark, at the east foot of Mt. Tom, Northampton, in 1848. Ichnology, page 127, Plate XLIV., fig. 2.

2. Slab of gray sandstone, 4° 2′ × 2° 6′, with several unfinished rows of Anisopus gracilis, one of Tridentipes uncus (?), one of an unknown animal, and a multitude (65) of impressions of Grammepus erismatus. From Dexter Marsh. Turner's Falls.

3, 4. Two slabs of red shale hardened by proximity to trap, each 3° 10′ × 1° 9′. Slabs split apart, showing rows of Grallator tenuis, Apatichnus circumagens, fine rain-marks and shrinkage cracks. 1855. Turner's Falls, near the trap-range. Ichnology, Plate LIII., fig. 5, page 73.

Total number of tracks on this Table, 136.

Table No. 13.

1. Slab of gray sandstone, two feet square, showing two rows and part of a third, of Plesiornis pilulatus, the type of the species. Also a fine row of Anisopus gracilis, one large track and impressions of an aroid plant. Tracks in relief. Figured in Ichnology, Plate XXXVI., fig. 4. See also, page 104. Turner's Falls, below the dam (?). 1855.

2. Gray sandstone slab, 5° 6′ × 1° 5′, broken in two at a joint. Row of six tracks of Chimæra Barratti on two layers; the upper one showing the heel of the hind foot and a short tail; the lower layer showing only the toes. Two fore feet are shown between the second and third large tracks, one of them quite distinct. Figured in Ichnology, Plate XXXVII., fig. 1. These tracks remind one of Tridentipes uncus. Turner's Falls, below the dam.

3. Hard reddish shale, 1° 6′ × 1° 1′, showing two tracks of Argozoum dispari-digitatum. A "mud-vein" is attached to one of the tracks, very much like a fourth toe. Cabotville. 1840.

4. Large slab, 9° 5′ × 5° 2′, of red shale, from the Orchard quarry at Turner's Falls. Tracks in relief. On front side the ichnites are remarkable for the distinctness of the phalanges and claws. There are the following tracks: (Two rows,) of Amblonyx giganteus — the type of the species — a row of four tracks of Brontozoum Sillimanium, a row and single tracks of B. exsertum, row and single tracks of B. validum, one track of Amblonyx Lyellianus, obscure vegetable fragments and

rain-marks. Figured in Ichnology, Plate XXXVIII., fig. 1. On the other face are twelve tracks in two rows of Stratipes latus, the type of the species, evidently formed under water, while the rain-marks show the others to have been above water. Yet the shale is only two inches thick. Hence there may have been tides or vertical movements of the land during the period of the Lithichnozoa. Also a multitude of vegetable fragments. Back side figured in Ichnology, Plate XLIX., fig. 4. The counterpart of this slab was purchased by the Boston Society of Natural History, at Marsh's auction in Greenfield, in 1853, at the same time No. 4 came to Amherst. 73 tracks on the slab.

5. Gray, hard sandstone, 3° 4′ × 1° 9′, from below Smith's Ferry. Tracks in relief of Brontozoum exsertum and Grallator cuneatus. 1854.

6. Same rock and locality, 3° 8′ × 1° 11′. Tracks of Brontozoum minusculum and B. exsertum.

7. Same as Nos. 5 and 6. Tracks of B. validum, B. exsertum and Grallator cuneatus.

8. Gray micaceous sandstone, 2° × 1°, showing two tracks of Argozoum dispari-digitatum. Wethersfield.

9. Reddish shale, 1° 9′ × 9′, with two tracks of Argozoum dispari-digitatum. Wethersfield.

10. Slab of Batrachoides nidificans, from South Hadley Falls.

Total number of tracks on this Table, 138.

TABLE NO. 14.

1. Gray micaceous sandstone, 1° 8′ × 1° 7′, showing seven or eight tracks in relief, of Grallator cuneatus. Turner's Falls. Obtained from Dexter Marsh.

2. Hard, gray, thick-bedded sandstone, 2° × 1° 9′, showing two depressed tracks of Argozoum Redfieldianum. On the under side, are two fine examples of coprolites, with toes in relief. Chicopee Falls. 1840. Ichnology, Plate LIX., fig. 6.

3. Same rock, 2° 10′ × 1° 10′, with two tracks of the same in succession; both defective. Coprolite on the underside. Chicopee Falls, from the middle of the stream in the dam above the bridge.

4. Large slab of reddish gray shale, 8° 6′ × 5° 3′, placed on edge and showing numerous ichnites and shrinkage cracks on both sides. On the upper side we have one row of three tracks of Brontozoum minusculum, besides a single track of the same, more slender, one track of B. validum and as many as six rows and several single tracks of Grallator cuneatus. Thirty-four tracks on this face, besides several trails, apparently of vegetable origin. The reverse side shows tracks in relief of Brontozoum tuberatum, B. minusculum (?), B. divaricatum, B. validum, B. Sillimanium and Grallator cuneatus. Turner's Falls. 1856. Ichnology, Plate XLII., fig. 3.

5. Red shale, 2° 5′ × 1° 7′, showing two rows of three hind impressions of Anomœpus curvatus, with one track of a fore foot, and tail mark of another species crossing the slab. Turner's Falls. 1856.

6. Red shale, 2° 3′ × 11′, showing on upper side, one track of Brontozoum Sillimanium, and parts of four others unknown. Below, row of four tracks of Tridentipes uncus. Turner's Falls. 1856.

7. Red shale, 2° 8′ × 1° 10′, with shrinkage cracks, and seven tracks of Grallator cuneatus. Turner's Falls.

8. Coarse gray sandstone, 2° 5′ × 1° 3′. Upper side covered with beautiful rain-marks. On reverse side, in relief, several short rows and single tracks of Grallator tenuis, as well as three tracks of Brontozoum Sillimanium, and an Anisopus. From the stream near Pliny Moody's, South Hadley. Presented by Rev. Plinius Moody.

9. Slab, 1° 9′ × 1° 7′. Like No. 3. Nos. 2, 3 and 9, the type specimens of Argozoum Redfieldianum.

Total number of tracks on this Table, 116.

Table No. 15.

1. Gray micaceous sandstone, 3° × 2° 4′, showing a single imperfect impression of Brontozoum giganteum, capacious enough to hold a gallon of water. See page 65 of Ichnology. From below Smith's Ferry.

2. Same rock, 1° 6′ × 10′, showing in relief, single track of Brontozoum giganteum. Below Smith's Ferry.

3. Same as No. 2, 1° 7′ × 1°, and interesting as being the first specimen of this species ever found. When first picked up, was thrown away as a lusus, the geologists then not having been educated to believe in the existence of large birds. 1835. Original type of the species. Figured in Amer. Journ. Sci., Jan. 1836; in Buckland's Bridgewater Treatise and Ichnology, Plate LVII., fig. 1, reduced. Smith's Ferry.

4. Cast of a large specimen of Brontozoum giganteum, from Smith's Ferry. Dug up by Dexter Marsh.

5. Slab, 1° 8′ × 1° 7′ showing Brontozoum giganteum in relief. From below Smith's Ferry, Northampton.

6. Slab, 2° 3′ × 1° 11′, with single tracks of Brontozoum approximatum and B. validum in relief. Smith's Ferry.

7. Slab of reddish shale, 2° × 1° 4′, showing single impressions of Brontozoum approximatum, B. validum and B. Sillimanium, with delicate rain-marks. Turner's Falls.

8. Hard sandstone, 2° 3′ × 1° 9′, used for a long time as a hearthstone at Smith's Ferry. Single impression of Brontozoum giganteum.

9. Slab of reddish shale, 1° 10′ × 1° 6′, showing two impressions of B. approximatum, rain marks and vegetables with seeds. Turner's Falls.

10. Gray micaceous sandstone, 1° 9′ × 1° 1′, showing single impression of Brontozoum approximatum. Smith's Ferry.

11. Single depressed track of Brontozoum giganteum. Slab, 2° 6′ × 2° 7′. Smith's Ferry.

12. Slab, 1° 9′ × 1° 3′, showing single impression of Brontozoum approximatum.

13. Micaceous sandstone, 2° 3′ × 2°, with single impression of Tridentipes ingens. Shows well on under side of slab. Horse Race, Gill.

14. Gray grit, 1° 10′ × 12′, showing poor impression of Brontozoum giganteum. Smith's Ferry.

15. Red micaceous sandstone, 2° 11′ × 1° 10′, showing three tracks of Tridentipes elegans. Turner's Falls.

16. Gray micaceous sandstone, 2° 10′ × 2° 6′, with one track in relief of Brontozoum giganteum, three of B. validum, and one of B. exsertum. Turner's Falls, below the dam.

17. Reddish shale, 2° 6′ × 1° 4′, with four tracks of Brontozoum validum. Turner's Falls.

18. Coarse sandstone, 1° 6′ × 1° 5′, with a single raised track of Brontozoum giganteum. Imperfect, but interesting from its locality — near Bassett's quarry, Easthampton — from the west face of Mt. Tom. 1858. Presented by Prof. E. Hitchcock, M. D.

Total number of tracks on this Table, 30.

Table No. 16.

1. Fine red shale, 5° 1′ × 1° 4′, containing a row of two tracks — the typical specimen — of Brontozoum minusculum, three of B. Sillimanium, one of B. exsertum, one of B. validum, two of Grallator cuneatus, a row of three tracks of Platypterna varica, one track of P. digitigrada, a tail trace (?) of Anomœpus major, a row of tracks of Saltator caudatus, delicate rain-marks, and row of Anisopus (?). Lily Pond. 1855. Ichnology, Plate XL., fig. 2.

2. Slab of sandstone, 2° 9′ × 1° 7′, showing a row of Anomœpus minor, and another of Ancyropus heteroclitus (?). From South Hadley, near Moody Corner. This specimen was ploughed up by Pliny Moody, in 1800. It was subsequently used for a door-step, then obtained by Dr. Dwight, of South Hadley, and finally bought by E. H., of his heirs. This is the earliest specimen of fossil footmarks anywhere preserved. The tracks were called by Moody, those of Noah's Raven. See page 3 of Ichnology.

3. Reddish shale, 2° 6′ × 12′, with three impressions of Anomœpus intermedius, one of A. gracillimus with a long tail trace; also a row of eight tracks of Ancyropus (?), with tail trace. Turner's Falls. From D. Marsh. Before 1853.

4. Red shale, 4° 6′ × 2°, placed on edge. On upper side, one example of the hind and fore feet of Anomœpus minor, with the long hind heel and an elliptical impression between them, made either by a tail or a projecting abdomen. After the animal had rested we can see at least one track as he moved forward on his hind feet. Several tracks of Platypterna varica, one of P. digitigrada, one of Brontozoum validum, one of B. exsertum, three or more trails of Cunicularius retrahens and other imperfect tracks, *e. g.* of Corvipes lacertoideus. On reverse side of slab, in relief, are two tracks of B. validum, one of Grallator cuneatus, a row of ten tracks of Exocampe minima, and trails of Unisulcus minutus. Field's Orchard, Gill. From Marsh's collection. 1853.

5. Red shale, 4° × 2°, placed on edge. Upper side covered mostly by fine ripple-marks formed after the tracks. Shows fine row of Anomœpus minor. At first three tracks of the toes of the hind feet are seen; then the animal sat down resting on its long heels, bringing down its small front feet. An ovoid impression between the tracks looks as if made by the body of the animal, or by a tail as it advanced. A doubtful track of the hind foot shows itself before the resting place. Type of the species. Ichnology, Plate IX., fig. 1.

On this side, also, may be seen an insulated track of the hind foot of A. minor, lower down, two of Grallator cuneatus, one of Brontozoum Sillimanium, and probably a tail trace near the bottom on a higher layer. On the reverse side we have one track of B. Sillimanium, one of B. validum, two of Grallator cuneatus, two hind feet, and fore foot of Corvipes lacertoideus, a row of two tracks of Anomœpus minor; other indistinct quadrupedal tracks and rain-marks. Turner's Falls. From Marsh's auction.

6. Gray micaceous sandstone, 7° 5′ × 5°, placed on edge. On upper side, two tracks of Brontozoum giganteum, with a stride of forty-five inches, thirty-two of B. exsertum, among which is the type of the species, one of B. Sillimanium, three of B. validum, two of Grallator cuneatus, two of doubtful character, and stipes of Clathropteris. On lower side, several obscure tracks of B. validum. Smith's Ferry. 1854. Ichnology, Plate XL., fig. 3.

7. Hard shaly sandstone, 3° × 2°, showing three tracks of Tridentipes elegans, others of T. uncus and mud veins. Turner's Falls.

8. Reddish shale, 3° 1′ × 1° 2′, with tracks of Brontozoum Sillimanium. Turner's Falls.

9. Gray sandstone, 3° × 1° 4′, with three tracks of Tridentipes elegans. Turner's Falls.

10. Reddish micaceous sandstone, 2° 11′ × 1° 6′. Eleven tracks of Anomœpus gracillimus, and rain-marks above, and two rows of A. gracillimus beneath. Turner's Falls.

11. Gray micaceous sandstone, 2° 2′ × 1° 6′, with two tracks of Brontozoum validum, two of Apatichnus (?) bellus, one of Grallator (?) tenuis, one of A. cuneatus (?) and others. Turner's Falls.

12. Gray micaceous sandstone, 2° 6′ × 1° 6′, with one track from below where the animal trod, of Tridentipes ingens. Horse Race, Gill. About 1840 (?).

13. Coarse, gray, micaceous sandstone, 2° 3′ × 1° 9′, with one track of Brontozoum divaricatum. Smith's Ferry.

14. Gray micaceous sandstone, 1° 8′ × 1° 6′, showing three tracks of the hind feet of

Anomœpus intermedius, and two tracks of the front foot, one very perfect. On the right a distinct tail mark. Also trails of Unisulcus minutus and Sphærapus larvalis. Turner's Falls.

15. Reddish shale, 1° 11′ × 9′, covered with rain-marks, showing four tracks of Anomœpus gracillimus. On reverse side, four or five tracks of Anomœpus. Turner's Falls. From Dexter Marsh.

Total number of tracks on this Table, 206.

TABLE NO. 17.

1. Reddish shale, 7° 3′ × 4° 9′, showing two tracks (a row) of Brontozoum giganteum, with stride of 45 inches, two rows of B. divaricatum, with stride of 41 inches, seven rows of Grallator cuneatus, one row of B. validum, trails of Unisulcus minutus, and innumerable vegetable impressions. Turner's Falls. 1856. Ichnology, Plate XLI., fig. 1.

2. Red shale, 3° 9′ × 3° 1′, showing in relief two imperfect tracks of Antipus bifidus, with strong tail trace, one row of Brontozoum Sillimanium, two of Grallator gracilis, and one of Plesiornis quadrupes (?). Ferry above Turner's Falls. Marsh's auction. 1853.

3. Similar slab, 4° 2′ × 2° 1′, with imperfect tracks in relief of Plectropterna (?) gracilis, Grallator gracilis, etc., poor. Ferry above Turner's Falls.

4. Similar slab, 4° 1′ × 2° 6′, with tracks of Grallator gracilis, Unisulcus minutus, and Anisopus gracilis. Ferry above Turner's Falls.

5. Slab, 2° 3′ × 12′, showing single track on both sides of Tridentipes ingens, with the large brush. Horse Race, Gill.

6. Micaceous sandstone, 2° 6′ × 1° 3′, with one track of Tridentipes ingens, and two of T. insignis, all impressed on a surface below that on which the animal trod. Turner's Falls.

Total number of tracks on this Table, besides the trails, 69.

TABLE NO. 18.

1, 2. Slabs of red micaceous sandstone, each about three feet square, with two rows of Tridentipes elegans. The slabs were split apart for flagging stone, the impressions having been made through them both, making a *folio* of four pages. Marsh's quarry, Montague. 1835. These are the slabs noticed by Messrs. Draper, Marsh, Wilson, and Deane; and by the latter, brought to the attention of Prof. HITCHCOCK. Purchased of Dr. Deane at their value as flags. Ichnology, Plate LII., figs. 9, 10, 11. Eight ichnites visible.

TABLE NO. 19.

1, 2. Small slabs of fine, gray, micaceous sandstone, with four impressions of Typopus abnormis. Type of the species. Ferry at Turner's Falls. Marsh's auction. Ichnology, Plate XLV., fig. 7.

3. Red shale covering micaceous sandstone, 2° 3′ × 12′, showing in relief two rows of Anomœpus gracillimus, A. minor, and rain-marks. Ferry at Turner's Falls. Marsh's auction.

4. Same stone, 1° 9′ × 1° 3′, with eight tracks of A. gracillimus and A. minor, one of Grallator tenuis, eight of Anisopus gracilis, and rain-marks. Two Anisopus tracks beautifully impressed one upon the other. Ichnology, Plate XXXIX., fig. 2. Marsh's auction.

5. Same stone, 2° × 1°, with twelve tracks of A. gracillimus, A. minor, with a tail trace, one of Anisopus gracilis, and rain-marks. Marsh's auction.

6. Hard grit, 1° 5′ × 12′, with five tracks in relief (hind foot,) of Plectropterna minitans. Chicopee Falls.

7. Gray micaceous sandstone, 2° 8′ × 2°, with tracks of Anomœpus minor upon both sides, also Grallator cursorius, and A. intermedius. Obtained of Dexter Marsh. Turner's Falls.

8. Reddish shale, 4° 6′ × 1° 10′, placed on edge. On upper side, a row of seven tracks of Tridentipes uncus, and five other imperfect tracks. On reverse side, two parallel trails of Helcura surgens, with two imperfect tracks of Brontozoum validum, and ripple-marks. Turner's Falls.

9. Slab like No. 8, 4° 3′, × 2° 9′. On upper surface, one row of three tracks of Platypterna varica, one of eight tracks of Tridentipes elegantior making a turn, (see Ichnology, page 91,) a row of three tracks of T. elegans, a trail of Helcura caudata, a broken track of Brontozoum minusculum, and three others doubtful. On reverse side, two fine tracks of Grallator formosus and Brontozoum Sillimanium. Ichnology, Plate XLV., fig. 1.

10. Red micaceous sandstone, 2° 9′ × 1° 10′, with three imperfect tracks of Brontozoum Sillimanium and Unisulcus Marshi. On reverse side, tracks of the same, one of Grallator formosus with perhaps trails of Unisulcus. Turner's Falls. Ichnology, Plate XLIX., fig. 2.

11. Red micaceous sandstone, 2° 4′ × 1° 9′, showing two tracks of Apatichnus (?) with tail trace, one or two trails of Unisulcus Marshi, type of the species, and perhaps a dozen of U. minutus upon the upper surface. Below are two or three impressions with rain-marks. Turner's Falls. From D. Marsh, before 1849. Ichnology, Plate XXVI., fig. 1, page 160.

12. Slab same as No. 11, 1° 5 × 13′, with Anomœpus gracillimus in relief above, and trail of Unisulcus Marshi, below. Ichnology, Plate XLIX., fig. 1.

13. Gray micaceous sandstone, 1° 6′ × 13′, with one track of Tridentipes ingens. From the "City," in Montague, a few rods east of the canal, on the old Boston road.

14. Gray micaceous sandstone, with a thin scale of red shale, 3° 10′ × 2° 1′. Three distinct rows of Anomœpus intermedius, showing the hind feet. A fourth row may be seen in the middle, one pointing the other way. There are two cases where the animal having moved on its hind feet alone, brought down its long heel and fore feet. The latter remarkably distinct, showing the number of phalanges. Also two isolated tracks of the fore foot. Turner's Falls. Marsh's auction. Ichnology, Plate XLIV., fig. 1.

15. A leaf, 1° 8′ × 1° 5′, split from No. 8, showing a part of the fine row of Tridentipes uncus.

16, 17. Small slabs, showing single tracks of Typopus abnormis. Ferry at Turner's Falls. Marsh's auction.

18. Gray micaceous sandstone, 2° × 11′, showing four tracks of Plesiornis quadrupes. Turner's Falls. Presented by Dr. James Deane. Figured in Trans. Amer. Ass. Geologists, Vol. 1, Plate XI.

19. Shale with two impressions of Brontozoum validum. Field's orchard, Gill. 1863.

20. Dark sandstone, with tracks in relief. Heel and hind foot of an Anomœpus, trail of Unisulcus Marshi (?), and several of U. minutus. Turner's Falls. 1863.

Total number of tracks on this Table, 200.

Table No. 20.

1. Red shale, 2° 10′ × 1° 9′, showing one track of Brontozoum exsertum, several of B. Sillimanium, one of Hyphepus (?) Fieldi, with a strong tail trace a little in advance, and two remarkable heart-shaped shallow impressions, corresponding with the caudal marks of Anomœpus major on Nos. $\frac{1}{1}$ and $\frac{1}{7}$. Figured in Ichnology, Plate XLIV., fig. 5. Slab also covered with the curious "triangular dents." Lily Pond. 1855. Ichnology, Plate XLIV., fig. 5.

2. Slab, 2° 1′ × 1° 3′, similar to the last and from the same locality, showing one impression of Gigantitherium minus, one of Brontozoum Sillimanium, and one tail trace.

3. Two slabs of reddish shale, each 1° 9′ × 12′, showing two tracks of Grallator cuneatus pointing in opposite directions. Also shrinkage cracks. Lily Pond.

4. Slab of hard, gray grit, with a thin coating of red shale, 2° 3′ × 1° 8′, with one distinct hind and one fore foot of Chimæra Barratti; two hind feet of the same, obscured by erosion, moving in opposite directions with a tail trace. Also a row of four tracks of Anisopus gracilis, and some rain-marks. This is the true type of the genus and species of Chimæra, rather than the one figured in Ichnology, Plate XXI., fig. 1. Fig. 4 is a hind foot more like the one on this slab. Fig. 1 may be another genus. From the sidewalk in Middletown, Connecticut, presented by Dr. Joseph Barratt. Tracks in relief.

5. Gray micaceous sandstone, 1° 10 × 1° 6′, with two tracks of Brontozoum validum and one of Apatichnus (?) circumagens. Turner's Falls.

6. Large slab of red shale, 9° × 7°, placed on edge, containing the following tracks, carefully studied by E. H. On west side of the slab in relief, are one row of three tracks of Gigantitherium minus with tail trace; one row of eleven tracks and tail trace of Hyphepus Fieldi; one row of twenty-one tracks of Anisopus Deweyanus; three rows of fourteen, nine and six tracks of Anisopus gracilis; one row of fourteen hind and two front feet of Apatichnus circumagens; three rows of four, three and three tracks of Brontozoum validum; one row of two tracks of B. tuberatum; two rows of four and three tracks of B. Sillimanium; one row of two tracks of B. exsertum; twelve rows of from two to four tracks of Grallator cuneatus; also four single tracks of Anisopus gracilis, one of G. cuneatus, and two of B. Sillimanium; several sea-weeds, numerous small seeds (?), and the triangular dents. In all twenty-six rows of tracks.

On the opposite side are the following impressions:—Two rows of two tracks of Brontozoum approximatum; one row of two tracks of Amblonyx Lyellianus; single tracks of B. minusculum, B. giganteum, B. exsertum, B. Sillimanium, and A. Lyellianus. Numerous small ripple-marks, formerly referred to Ptilichnus pectinatus, and shrinkage cracks. From Lily Pond. 1855. Presented by R. Field. In Ichnology, Plate XLI., fig. 2. 159 ichnites on the slab.

7. Slab of red shale, 4° 4′ × 3° 4′, placed on edge, containing two rows of seven tracks each of both feet of Plesiornis quadrupes, one row of two tracks of the hind feet of same, one row of single hind and front feet of same, a row of two tracks of Brontozoum (?) exsertum, one row of four tracks of both feet of Exocampe arcta (?), two single tracks of Anomœpus gracillimus, one of G. cuneatus, four or five single tracks of P. quadrupes and several branches of Cunicularius retrahens. All impressions. The reverse side is the surface from which No. $\frac{19}{9}$ was taken. This is larger and shows in relief two tracks of Tridentipes elegantior in a row, two of T. elegans, five of Platypterna varica, and rain-marks. Turner's Falls. Marsh's auction. Ichnology, Plate XLV., fig. 5.

8. Red micaceous sandstone, 1° 6′ × 1° 4′, showing single track of Brontozoum divaricatum in relief, with rain-marks. Turner's Falls.

9. Red shale, 3° 1′ × 1° 10′, showing one track of Brontozoum minusculum, one of B. validum (?), a row of three tracks and single track of Tridentipes elegantior, a row of Ptilichnus anomalus—four trails of the fin—several rows of Sphærapus larvalis, one row of eight tracks of Grammepus (?) erismatus and one trail of Bisulcus undulatus. Lily Pond. 1855.

10. Red shale, 2° 8′ × 1° 6′, showing multitude of fine rain-drops, two tracks of Platypterna varica, and two of Tridentipes elegantior. On reverse side one good track of Grallator cuneatus (?). Lily Pond. 1856.

11. Red micaceous sandstone, 1° 8′ × 1° 5′, with one track of Brontozoum Sillimanium, and numerous trails of Unisulcus minutus. Turner's Falls.

12. Slab, 1° 10′ × 1° 3′, with tracks of Brontozoum validum, B. Sillimanium, and B. exsertum. 1861. Horse Race.

Total number of tracks on this Table, 365.

Table No. 21.

The specimens upon this Table were badly broken by the accidental fall upon them of No. $\frac{26}{9}$, and have been repaired as well as possible, but probably the descriptions will be defective.

1. Slab of red shale, 4° × 3° 8′, containing the following rows:—One of ten tracks of Anisopus Deweyanus; one of thirteen and two single tracks of A. gracilis; one of two tracks of Brontozoum exsertum; one of two tracks of B. validum; two of two tracks each of B. Sillimanium; two of two tracks each of Grallator cuneatus; one of three tracks of Apatichnus circumagens; one of four tracks of A. bellus; one of five tracks of Platypterna digitigrada, with one track of Grallator cursorius, a few of doubtful name, and numerous indentations. Broken into a number of fragments of which the four largest are preserved. From Lily Pond. 1855.

2. Two slabs, 2° 6′ × 1° 6′, badly broken and partly cemented, of gray sandstone, with three (part of a fourth) tracks of Apatichnus circumagens. It shows a tail trace, also a trail of the claw. On the under side, a front and hind foot are shown more distinctly than upon any other slab in the Cabinet, and the specimens are the type of this interesting species. Turner's Falls.

3. Gray sandstone, 2° 5′ × 1° 3′, with two rows of two and three impressions of Anomœpus gracillimus, one of A. minor, and one of Brontozoum Sillimanium. On the under side in relief, are several tracks of A. intermedius (?), without the heel. Turner's Falls. From Marsh's auction.

4. Fragment broken from No. 3, 12′ × 11′, with tracks of A. minor in relief, and impressed with one of Brontozoum Sillimanium.

5. Red shale, 2° 3′, × 1° 6′, showing on the upper side, a row of two hind and one fore track of Apatichnus circumagens, two of Anomœpus minor, one of Brontozoum tuberatum, and impressions of rain-drops. In relief are two rows of nine and six tracks of Plectropterna gracilis, with trails of the claws and tail. One row of two tracks of Platypterna varica, and two single tracks of Grallator cuneatus. Turner's Falls. From Marsh's auction.

6. Gray sandstone, 3° 9′ × 2′, with ten impressions of Tridentipes elegans. Horse Race, Gill. About 1842.

7. Gray micaceous sandstone, with seven impressions (five showing themselves in relief on the lower side,) mostly of Tridentipes elegans. Horse Race, Gill. About 1842.

8. Gray micaceous sandstone, 2° 5′ × 2°, with eight tracks in relief of Tridentipes elegans. Horse Race, Gill. About 1842.

Total number of tracks on this Table, 133.

Table No. 22.

1. Slab, 14° 6′ × 2° 6′, with seven impressions of Brontozoum minusculum, several in a row, six of B. validum, twenty-seven of B Sillimanium, and one of Grallator cuneatus. Also a row of eight indistinct small quadrupedal impressions. Horse Race, Gill. 1863.

Total number of tracks on this Table, 49.

Table No. 23.

Next to west wall of room.

1. Red shale, 3° × 2° 9′, with two tracks of Brontozoum validum and innumerable rain-marks. Turner's Falls.

2. Gray sandstone, 2° 10′ × 2° 8′, with one row of three tracks of Grallator cursorius, two tracks with a tail trace of Antipus bifidus, the type of the species; one row of three tracks of Anomœpus minor, one hind and fore foot (?), with rain-marks. All impressions. Turner's Falls. From D. Marsh. Ichnology, Plate XLVIII., fig. 10, XXXVI., fig. 8.

3. Gray sandstone, 2° 11′ × 1° 6′, with two tracks of Antipus bifidus, ten of both feet of Anomœpus minor, imperfect, and rain-marks. Turner's Falls. From D. Marsh.

4. Slab of reddish sandstone, 2° 4′ × 1° 6′, of impressions of rain-drops, and Unisulcus intermedius. No. $\frac{22}{2}$ of Ichnology. Turner's Falls.

5. Reddish shale, 2° 6′ × 1° 3′, with deeply impressed rain-marks, one indistinct row of two tracks of Anomœpus minor, both feet with tail; two isolated tracks, perhaps of Ornithopus, and one other doubtful track, perhaps of Anomœpus. Reverse side contains a row of two tracks of hind foot of A. minor, with two or three tracks of the same moving in opposite directions. Also four tracks of Anisopus gracilis — all in relief. Turner's Falls.

6. Micaceous sandstone, 3° × 1°, with one row of five tracks of Tridentipes uncus. Turner's Falls. Marsh's auction.

7. Coarse sandstone, 1° 4′ × 1° 3′. $\frac{22}{15}$ of Ichnology. One track of Brontozoum validum, and impressions of rain-drops. South Hadley, opposite Smith's Ferry.

8. Red micaceous sandstone, 4° × 2° 6′, with one row of five tracks of the hind foot of Apatichnus circumagens — two showing the fourth toe, — two rows of ten and four tracks of Anisopus gracilis, two rows of four and two tracks of Grallator gracilis, two rows of five and two tracks of a strange Grallator — remarkable for the heel, which shows three ridges. Ferry at Turner's Falls. Marsh's auction.

9. Coarse micaceous sandstone, 5° 6′ × 2° 6′, with two large tracks of Brontozoum giganteum. Smith's Ferry. 1854. Ichnology, Plate IV., fig. 2.

10. Gray coarse sandstone, 1° 3′ × 1° 2′, with shrinkage cracks. Portland quarries, Connecticut. 1857.

11. Slab of shale, 11° × 3° 5′, with twenty-eight tracks, large and small, of Brontozoum divaricatum, and one of B. Sillimanium. Turner's Falls. 1863.

12. Reddish sandstone, 2° 9′ × 2° 4′, with about twelve impressions of Anomœpus, chiefly of A. curvatus. Ferry at Turner's Falls.

Total number of tracks on this Table, 108.

Wall No. 24.

1. Large slab of red shale, 7° 9′ × 4° 5′, showing impressions of two rows of two and three tracks of Brontozoum exsertum, one row of two tracks of B. validum, three rows of two and three tracks and two single tracks of Grallator cuneatus, one track of B. giganteum, and one row of Anisopus gracilis. In all thirty-three impressions. Also a few shrinkage cracks. Lily Pond. 1856. Ichnology, Plate XLIII., fig. 1.

Wall and Table No. 25.

1. Large slab of red shale, 7° × 6°, showing on a surface abounding in shrinkage cracks, impressions, viz.: One row of two tracks and two single tracks of Gigantitherium minus, three rows of two and three tracks of Grallator formosus, four rows of two tracks, four rows of three tracks, and one row of four tracks of Grallator cuneatus, besides twenty-five single tracks of the same, two tracks of Brontozoum divaricatum, and row of eleven tracks of Argozoum pari-digitatum. Lily Pond. 1856. Ichnology, Plate XXXIX., fig. 1.

2. Smaller slab from same locality. Shows three rows of two tracks, and four single tracks of G. formosus, ten single tracks of G. cuneatus, one of Brontozoum validum, one of B. divaricatum, and mud veins. Ichnology, Plate XLVII., fig. 5.

3. Gray shale, 2° 2′ × 1° 9′, with seventeen tracks of Ornithopus gracilior. Turner's Falls, below the dam. Before 1848.

4. Reddish shale, 4° × 3° 5′, showing impressions, viz.: One row of fifteen tracks of Exocampe ornata; one row of eight tracks, two front, of Plectropterna gracilis; one row of eight tracks of both feet of Corvipes lacertoideus; single tracks of Brontozoum minusculum and B. tuberatum; five of Grallator cuneatus; one row of two tracks of Tridentipes uncus, and another of two tracks of Platypterna varica. Lily Pond. 1856. No. $\frac{22}{1}$ of Ichnology, Plate XLVII., fig. 1.

5. Red sandstone, 4° 10′ × 5° 6′, with two impressions of B. tuberatum, one of B. exsertum and a row of three tracks of Grallator cuneatus, and vegetable fragments. (Under the table.) Turner's Falls.

Total number of tracks on this Wall, 176.

Table No. 26.

1. Slab, 3° × 1° 6′. Shrinkage cracks and rain-marks. Turner's Falls. Ichnology, Plate LVI., fig. 3.

2, 3. Thick red sandstone, 2° 6′ × 1° 7′, with shrinkage cracks. Remarkable for the rounded form of the pieces. Newark, N. J. 1855. Ichnology, Plate LVI., figs. 1, 2. Called facetiously, "Nature's Hieroglyphics."

4. Red sandstone, 2° 7′ × 10′, with four tracks of Isocampe strata and what is called a tail-trace in Ichnology. It was supposed that the tracks on the other side of the tail-trace had been broken off. Possibly the supposed tail-trace may be a Cunicularius. Portland, Connecticut. Ichnology, Plate XXXVI., fig. 5.

5, 6. Hard gray shale, 2° 6′ × 2° 4′, with rows — both impressed and elevated — of fifteen tracks of both feet of Anisopus Deweyanus. Large shallow depressions of uncertain origin. Stone indurated by heat. Ichnology, Plate LIII., fig. 8.

7. 8. Gray shale, 4° 3′ × 2° 3′, 3° 3′ × 2° 2′, covered with tracks of Anisopus gracilis and ripple-marks. Horse Race, Gill. Ichnology, Plate XLIII., figs. 4 and 5.

9. Slab, 3° 3′ × 7′, with row of ten tracks of hind feet of Exocampe ornata. Lily Pond. Ichnology, Plate XLVIII., fig. 1.

10. Large slab, 3° 9′ × 3° 7′, with impressions, viz.: Four rows of hind feet of Anomœpus intermedius; row of ten tracks of both feet of Anisopus Deweyanus; two trails of Helcura caudata, and numerous rain-marks. Field's Orchard, Turner's Falls. Dug up by D. Marsh. Ichnology, Plate XL., fig. 1.

11. Coarse white sandstone, 2° × 16′, with one perfect and two imperfect hind feet of Cheirotherium Barthii, Kaup, Hilderberghausen in Saxony. Trias.

12. Same rock and locality, 14′ × 10′, with two tracks of C. Barthii, hind and front feet nearly perfect. Also as many as four tracks of some undescribed lizard.

13. Same rock and locality, 12′ × 8′. Single hind foot of a Cheirotherium, hardly like C. Barthii, lying upon a vegetable stem, and a similar relic by its side. Nos. 11 to 13 in relief.

14. Hard sandstone, 1° 9′ × 11′, of the coal formation, from S. W. Pennsylvania. Five tracks in relief of Thenaropus heterodactylus, King. Shrinkage cracks abound, some of which proceed from the ends of the toes, and convey a wrong impression to those not conversant with such phenomena. Before 1848.

15, 16, 17. Shale slightly calcareous, the last in relief. Tracks of Polemarchus gigas, the type specimens. Nos. 15 and 16, from middle of the river at Chicopee Falls; 17 from a quarry half a mile south of Cabotville on the Springfield road. Before 1848. Ichnology, Plate LIX., fig. 3.

18. Sandstone 1° 10′ × 1° 7′, showing in very distinct relief, eighteen tracks of Brontozoum Sillimanium and Grallatòr formosus. South Hadley, N. W. of Moody Corner, in the stream. Presented by Rev. Plinius Moody. Ichnology, Plate XLIII., fig. 6, page 68.

19, 20. Slabs, 2° 5′ × 1° 3′, 1° 9′ × 1° 6′, like Nos. 7 and 8, with tracks of Anisopus gracilis. From Horse Race, Gill. 1856.

21. Red shale, 4° 6′ × 2° 3′, showing one row of four tracks of Tridentipes elegans, the hind toe especially; one row of fourteen hind tracks of Apatichnus bellus, besides two rows of seven tracks of the same, and traces of at least five fore feet; one row of six tracks of hind feet of Apatichnus bellus, and numerous tracks of Grammepus erismatus. Besides are numerous small single lines of ichnoid character. Turner's Falls. Ichnology, Plate XLV., fig. 6.

22. Removed to $\frac{28}{5}$.

23. Red sandstone, 2° 3′ × 1° 6′, containing two rows of five, and one of four tracks of Argozoum pari-digitatum, and two tracks of Tridentipes uncus. Turner's Falls.

24. Red sandstone, 3° 8′ × 12′, with a row of six tracks of the hind foot of Plectropterna gracilis, and one track of an unknown species. Turner's Falls.

25. White sandstone, 1° 7′ × 1° 1′, containing in relief, one hind and two front tracks of Cheirotherium. From the Storeton quarries, near Liverpool, England.

26. Same rock and locality, 1° 5′ × 9′, with single hind and fore feet in relief, of the Cheirotherium.

Total number of tracks on this Table, 443.

Case No. 27.

In first side-room.

The tracks in this case are mostly quite small, and in the form of "books," or different strata showing the same tracks, and fastened by hinges. Called the "Stony Library."

1. Soft gray shale in two leaves, with eight hind and fore feet of Macropterna vulgaris. This is the "*Ledger*." North bank, below Turner's Falls. Ichnology, Plate LII., fig. 3.

2. Reddish shale, with two tracks in succession, shown on the outside and inside of Platypterna Deaniana. There is a third track on the outside, which does not show through. This specimen shows how much impressions may alter in passing through even an inch of stone. Turner's Falls.

3. Red shale, showing four tracks of both feet of Macropterna divaricans without the heels. Turner's Falls. Ichnology, Plate LIII., fig. 4.

4. Five leaves of micaceous sandstone with two tracks of Platypterna varica, showing through them all. Turner's Falls. Marsh's auction. Ichnology, Plate LII., fig. 6.

5. Two leaves of shale, showing ten tracks with traces of the toes and tail of Orthodactylus linearis. Turner's Falls. Ichnology, Plate VI., fig. 7. Tracks mostly of the hind feet resembling those of the living Menobranchus.

6. Two leaves of gray shale, with tracks of Ornithopus gracilior. Turner's Falls, north bank, below dam.

7. Four leaves of brown shale, showing the fore foot of Ancyropus heteroclitus. The second leaf shows Conopsoides larvalis, and something similar on second leaf. On third leaf, also, tracks of an unknown animal. Wethersfield Cove. Twenty-eight tracks. Ichnology, Plate LIII., fig. 2.

8. Three leaves of gray shale, showing Ornithopus gracilior. North bank, below Turner's Falls.

9. Two leaves of red shale, with three tracks of Triænopus leptodactylus. Wethersfield Cove. Ichnology, Plate LII., fig. 1.

10. Two leaves of gray shale, showing five tracks of hind feet and one of fore foot of Xiphopeza triplex. North bank of Connecticut River, below Turner's Falls. Ichnology, Plate LII., fig. 4.

11. Two leaves of gray shale, with two rows of tracks (six of hind feet,) of Xiphopeza triplex. Same locality as No. 10. Ichnology, Plate LII., fig. 2.

12. Three leaves of gray shale, showing tracks of hind foot of Ancyropus heteroclitus. Wethersfield. Fore feet on No. 7. Ichnology, Plate LIII., fig. 1.

13. Two leaves of gray shale, showing three tracks of hind feet of Xiphopeza triplex. Turner's Falls, below dam.

14. Three tracks of the same. Ichnology, Plate LIII., figs. 3, 6.

15. Two leaves of red shale, with two rows showing nine hind and five front feet impressions of Orthodactylus linearis. Turner's Falls. Ichnology, Plate XLVIII., fig. 4.

16. Two leaves of red shale, with single track of Brontozoum Sillimanium. Turner's Falls.

17. Two leaves of red shale, with single track of Brontozoum tuberatum, showing phalanges and claws very distinctly. Turner's Falls. Ichnology, Plate LII., fig. 7.

18. Two leaves of shale, with two hind foot tracks of Harpedactylus gracilis. Below Turner's Falls. Ichnology, Plate LII., fig. 5.

19. Two leaves of red shale, with two tracks, not consecutive, of Triænopus leptodactylus. Heel long and peculiar at its end. Wethersfield Cove.

20. Same as 19, except tracks are consecutive.

21. Slab, 4° 6′ × 3° 6′, with numerous impressions of Ænigmichnus multiformis in front, and casts of rain-drops and trail of Sphærapus larvalis behind. Ferry above Turner's Falls. Supplement, Plate XIV., page 21.

Not including No. 21, there are 94 impressions, repeated to 163, in Case No. 27. Including No. 21, there are 3,355.

TABLE NO. 28.

The Table numbered $\frac{28}{1}$ in the Ichnology, is now No. $\frac{58}{2}$.

1. Slab of red sandstone, 6° 9′ × 3° 2′, with rows of impressions of hind feet of Anomœpus minor, A. gracillimus, A. minimus, Brontozoum Sillimanium, Grallator formosus, G. cursorius, G. parallelus, and impressions of rain-drops. In all 44 tracks. Field's Orchard, Gill. 1862.

2. Thick slab of red sandstone, 2° 2′ × 8′, with impressions like tracks, but only indicating a concretionary structure. From the quarries at Portland, Connecticut. 1857.

3. Red sandstone, 3° 6′ × 2° 4′, with numerous casts of rain-drop impressions, trails of Sphærapus larvalis, with two tracks and a tail trace of an Orthodactylus. Ferry above Turner's Falls. 1863.

4. Red sandstone, 2° 8′ × 2° 6′, with numerous impressions of rain-drops, one track of Tridentipes elegans, two trails of Sphærapus larvalis, a row of nine tracks of hind feet of an Anisopus, and a row of nineteen tracks of Exocampe ornata, with a row of similar tracks parallel to them. Ferry above Turner's Falls. 1863.

5. Red sandstone, 3° 6′ × 2° 2′, with five tracks in relief of Brontozoum Sillimanium, four of B. exsertum, one of B. validum and a number of shrinkage cracks. Portland quarries, Connecticut. 1857.

6. Slab of red sandstone, 5° 6′ × 3° 6′, counterpart of No. 3, covered with hundreds of beautiful impressions of rain-drops, and exhibiting a trail of Sphærapus larvalis. Ferry above Turner's Falls. 1863.

7. Slab of red shale, 17′ × 15′, showing on the upper side, two impressions of the hind feet of Apatichnus circumagens, and a few rain-drops. In relief, are one row of four tracks of Argozoum pari-digitatum, one row of four tracks of Anisopus gracilis, one row of ten tracks of Grallator gracilis (?), and four more tracks of A. gracilis. Turner's Falls.

Total number of tracks on this Table, 119.

Table No. 29.

1. Red shale ten feet long, placed on edge, and broken off from No. $\frac{20}{6}$. On the upper side are two single impressions of Brontozoum giganteum, one of B. approximatum, and one row of two tracks forty-eight inches apart; also a few shrinkage cracks. On the under side in relief, are the following:—One crooked row of eleven hind and five front tracks of Apatichnus circumagens. This is the row that first revealed the character of the animal. Two rows of four and one of two tracks and one single track of Hyphepus Fieldi; two rows of two and three tracks and one single track of Grallator formosus; six rows of from two to seven tracks and two single tracks of G. cuneatus; single tracks of Brontozoum approximatum, B. validum; two heels and one hind foot of Anomœpus major; two of both feet of Anisopus gracilis; one row of eight tracks of Anisopus gracilis; one row of eight tracks of A. Deweyanus; one row of two tracks of Brontozoum tuberatum (Gigantitherium minus) (?), and one row of six tracks of Apatichnus (?) bellus. Lily Pond. 1855. Ichnology, Plate XLII., fig. 1.

2. Coarse red sandstone, 2° 6′ × 1° 5′, and five inches thick, containing at least eight tracks of Cunichnoides marsupialoideus, with say twenty trails of Cunicularius, probably of more than one species. The type specimen of Cunichnoides. Presented by one of the freestone companies at Portland, Connecticut. 1857. Page 55, Plate IX., fig. 5, LX., fig. 2.

3. Same rock, 3° × 1° 11′, with one and part of another deep ovoid impression, made probably by the abdomen and posterior part of the animal as it moved forward. The impressions of the feet were wider apart than the width of this slab, as shown on another slab too heavy for transportation. Referred to Hoplichnus equus. Portland, Connecticut. Ichnology, page 65, Plate LX., figs. 3 and 4. A tail-trace crosses this specimen. Another impression resembles the print of a human shoe. At several inches distance is another similar impression, probably connected with the principal one, and it is probably a heel; so that what appears like the heel of the shoe may be the toe of the animal. It is certainly not of human origin.

4. Slab of rain-marks, impressions, 2° 9′ × 1° 9′. From Turner's Falls. Marsh's auction. No. $\frac{22}{19}$ of Ichnology.

5. Red shale, 1° 6′ × 14′, with irregular wave-marks. Turner's Falls.

6. Gray shale, 3° × 1° 7′, with twenty tracks, mostly of Anisopus gracilis, some of them perhaps of Exocampe. Turner's Falls.

7. Reddish shale, 1° 6′ × 1° 7′, with tracks of both feet of Apatichnus circumagens; four tracks of Anisopus gracilis; one of Grallator cuneatus, and a tail-trace with the triangular indentations. Turner's Falls.

8. Gray shale, 3° 6′ × 1° 5′, with thirty-seven tracks of Anisopus gracilis, one of Brontozoum validum, and one of B. Sillimanium. Horse Race, Gill.

Total number of tracks on this Table, 196.

Wall No. 30.

1. Large slab, 10° × 4°, with one fine typical row of Brontozoum validum, and two single tracks of the same. The row a curved one. Four rows of two and three tracks, and four single tracks of Grallator cuneatus; imperfect traces of two large tracks, B. giganteum (?), and shrinkage cracks. Twenty-two in all. Lily Pond. 1855. Ichnology, Plate XXXIX, fig. 3.

2. Reddish shale, 10° × 4°, all impressions, shows rows of Hyphepus Fieldi, one row of five tracks; Gigantitherium caudatum, one row of three tracks, rather imperfect; G. minus, two tracks and two single ones; Grallator cuneatus, three rows of three and five of two tracks; Platypterna

varica, two rows of three tracks; Anomœpus major, one row of two tracks and one heel; tracks of small quadruped, perhaps Macropterna vulgaris, common on the slab. Lily Pond. 1855. Ichnology, Plate XLIV., fig. 6.

3, 4. Curious ripple-marks, 3° × 8′, counterparts. Turner's Falls.

Total number of tracks on this Wall, 59.

The Cases Nos. 31 to 41 are upright, and arranged in order along the platform. The specimens are all small, and I shall not attempt to give their dimensions except in special instances.

Case No. 31.

1. Row of five tracks of Exocampe arcta, hind feet, on gray shale. Turner's Falls.
2. Ornithopus gallinaceus, on shale.
3. Three tracks of Grallator cuneatus; and on the reverse side one track, perhaps of the same. Turner's Falls.
4. Very perfect hind and front feet of Anisopus gracilis. Turner's Falls.
5. Shale, with one track of Brontozoum exsertum. Turner's Falls.
6. Black shale, with one track of Anomœpus gracillimus (?). Chicopee Falls.
7. Red shale, with tracks of Plesiornis æqualipes and Platypterna tenuis,—12 in all. Wethersfield Cove.
8. Red shale, with hind and front feet of Exocampe ornata (?). Wethersfield Cove.
9. Plectropterna minitans, on shale. Chicopee Falls.
10. Argozoum pari-digitatum, on micaceous sandstone. Horse Race, Gill.
11. Two leaves of red shale, with two tracks of Platypterna delicatula. Wethersfield Cove.
12. Argozoum pari-digitatum, on gray sandstone. Horse Race, Gill.
13. Harpedactylus gracilis, on gray sandstone. North bank, below Turner's Falls.
14. Red sandstone, with hind foot (?) of Chimæra Barratti. Marsh's quarry, Montague. E. H. remarks upon this specimen, that the characters of the Chimæra seem to be not well settled. Ichnology, Plate LIX., fig. 5.
15. Grallator cuneatus, on reddish shale. Wethersfield Cove.
16. Brontozoum validum and B. Sillimanium, on red sandstone. Turner's Falls.

17, 18, 19, 20. Single tracks of Brontozoum validum, and B. exsertum, on gray micaceous sandstone. From beneath the trap on Mt. Holyoke, a very interesting locality.

21. Unbound volume of four leaves, showing upon each leaf a single track of Plectropterna minitans. Wethersfield Cove.
22. A single track in relief of Brontozoum giganteum, showing the papillæ and striæ of the animal's foot. Very few other specimens of this kind in the Cabinet. Wethersfield Cove.
23. Two tracks of Triænopus leptodactylus, on red shale. Wethersfield Cove.
24. Triænopus leptodactylus, nine tracks upon both sides. Red shale. Wethersfield Cove.
25. Twelve tracks of Triænopus leptodactylus, on red shale. Wethersfield Cove.
26. Twenty-three tracks of Triænopus leptodactylus, on red shale. Wethersfield Cove.
27. Same number, etc., as 26. Ichnology, Plate XLV., fig. 8.
29. Fourteen tracks of Triænopus leptodactylus, on red shale. Wethersfield Cove.
30. One track of Triænopus leptodactylus, with a toe (perhaps) coming out from the heel and pointing forwards. Red shale. Wethersfield Cove. (Nos. wanting to 35.)
35. One track of Triænopus leptodactylus, showing a toe similar to No. 30. Red shale. Wethersfield Cove.

36. Four tracks of Triænopus leptodactylus, with a single track on the lower side, of Typopus gracilis, the typical and only specimen of the latter species. Red shale. Wethersfield Cove.

37. Two tracks, probably hind and fore feet of Triænopus leptodactylus. Two leaves in part. Red shale. Wethersfield Cove.

38. One track of same, from same locality.

39. One fair track of Triænopus leptodactylus, with a broad heel, and two other tracks. Red shale. Wethersfield Cove.

40, 41. Two unbound leaves of red shale, from Wethersfield Cove, with tracks of T. leptodactylus.

42. Ten tracks of the same on both sides of slab. One with a hind toe pointing backward from the end of a narrow heel. Same locality.

43, 44. Two leaves, unbound, showing at least two tracks of the Triænopus in nearly the same place, and even a third, perhaps.

45. At least seven tracks of Triænopus leptodactylus, two of them very small and of a doubtful character.

46. Counterpart of No. 36, Typopus gracilis.

47, and 50. Two leaves, containing fifteen tracks of the T. leptodactylus.

48. Five tracks of the same.

49. Eight tracks of the same.

51, 57, 58, 59. These slabs make four leaves of shale, with a track of Triænopus leptodactylus, showing a long heel.

52. Three tracks of Triænopus leptodactylus.

53. Five tracks of the same.

54. Two impressions—probably hind and fore feet—of the same. They occupy very nearly the same place.

55. Ten tracks of the same species.

56. Five tracks of the same, one of which shows a hind toe on a long heel, and a remarkable break in the heel. Nos. 43–59, on red shale. From Wethersfield Cove.

60. Spheropezium thærodactylum, *King*. On coarse grit of the coal measures. Westmoreland, Pa. Like the ten following numbers, artificially cut by Indians.

61. Sphæropezium ovoidactylum, *King*. Westmoreland, Pa.

62, 63. Ornithichnites Culbertsonii, *King*. Westmoreland, Pa.

64. Cast of Sphæropezium leptodactylum, *King*.

66. Cast of Sphæropezium thærodactylum, *King*.

67. Cast of Ornithichnites galinuloides, *King*.

68. Cast of Ornithichnites Culbertsonii, *King*.

69. Cast of Sphæropezium ovoidactylum, *King*.

70. Cast of Sphæropezium pachydactylum, *King*. The originals of Nos. 64 to 70, from Westmoreland, Pa.

71. One track of Brontozoum validum, on gray grit. Smith's Ferry, Northampton.

72. One track of Brontozoum exsertum, on grit. Smith's Ferry, Northampton.

73. One track of Brontozoum validum, showing phalangeal impressions very finely. Perhaps the type of the species. On red shale. Turner's Falls. Ichnology, Plate LVII., fig. 3.

74. Fine single track of Ornithopus gracilior, showing the impression of the end of the hind toe. Red shale. Wethersfield Cove.

75. Same, showing more of the hind toe.

76, 77. Two leaves of red shale, from Wethersfield Cove, with two tracks of Triænopus leptodactylus, showing a broad heel.

79. One track of Plesiornis æqualipes, with one of Platypterna tenuis, on red shale. Wethersfield Cove.

80. Ornithopus gallinaceus, on red shale. Wethersfield Cove.

81. Triænopus leptodactylus, on red shale. Wethersfield Cove.

82. Two leaves showing Plectropterna minitans. Wethersfield Cove.

83. Single track of Triænopus leptodactylus, on red shale. Wethersfield, Connecticut.

84. Three tracks of Plesiornis quadrupes, on gray sandstone. Turner's Falls. Presented by Dr. James Deane, of Greenfield.

85. Depressed tracks of Amblonyx Lyellianus, on red sandstone, Turner's Falls, showing the phalangeal impressions distinctly, but not deep. Presented by Dr. James Deane. Ichnology, Plate LVII., fig. 6.

86. Two impressions of Plesiornis quadrupes, with rain-marks. Turner's Falls.

Total number of tracks in this Case, 259.

Case No. 32.

1. Sandstone, from Turner's Falls. On the upper side, two tracks of the hind foot of Corvipes lacertoideus, pointing in opposite directions, and one fine fore foot impression; also a third hind foot. On the reverse side, seven tracks of Anomœpus gracillimus, and one trail of Cunicularius retrahens.

2. Slab of red sandstone, from South Hadley, north part, with two tracks of Brontozoum Sillimanium.

3. Slab with three tracks of Tridentipes uncus, from Turner's Falls.

4. Gray sandstone, with a single, quite small track of Tridentipes elegans, showing a brush on the heel. Horse Race, Gill.

5. Two tracks of Macropterna divaricans, from the Horse Race, Gill.

6. Two tracks of Macropterna divaricans; also an obscure track of the fore foot, a little in advance of the hind foot, brought to light by grinding down the surface. Four tracks.

7. Single track of Plectropterna (?) minitans, on sandstone, with some rain-marks. On the under side, singular convolutions, produced perhaps like ripple-marks. Wethersfield.

8. Hard black shale, with one track of Plectropterna minitans, and two of Plesiornis pilulatus (?). Chicopee Falls. Two specimens with this number making a book.

9. Black shale with six impressions of Harpagopus dubius. Turner's Falls. E. H. says:—"This is a singular impression, and my judgment vibrates to one side and the other, whether it be a real track." Ichnology, Plate LI., fig. 5.

10. Shale, with one track of Macropterna vulgaris (?). North bank, below Turner's Falls.

11. Red shale, with one track of Plesiornis æqualipes. Wethersfield.

12. Red shale, with one track of Ancyropus heteroclitus, (a little doubtful.) Wethersfield.

13. Gray shale. Turner's Falls. Track too obscure for identification.

14. Part of two tracks of Platypterna Deaniana. Shows the curvature of the layers of shale by the weight of the animal. Wethersfield.

15. Unknown species of track, with three (possibly four) toes. Turner's Falls.

16. Gray sandstone, with two tracks of Anisopus Deweyanus. Turner's Falls.

17. Shale, with one track of Exocampe arcta. North bank, below Turner's Falls.

18. One track of Anisopus gracilis, on coarse sandstone. Turner's Falls.

19. Shale, showing hind foot of Ancyropus heteroclitus, probably. North bank, below Turner's Falls.

20. Front foot of Anisopus gracilior. Turner's Falls.

21. Reddish shale with two tracks of hind feet of Plectropterna gracilis, and one trail of Sphærapus magnus. Turner's Falls.

22. One track of Brontozoum exsertum. Northampton.

23. Two leaves of red shale, showing a track on each of Platypterna Deaniana. Wethersfield.

24. Red shale with calcigrade track of Platypterna Deaniana. On the under side, the track is thrown forward an inch, showing that the animal was descending a slope. Wethersfield Cove.

25. Red shale. Wethersfield. Numerous tracks obscured by intermingling on upper side. On other side, four tracks of Ornithopus gallinaceus.

26. Red shale. On upper side three tracks of Triænopus leptodactylus, and one of Platypterna Deaniana. Wethersfield.

27. Three calcigrade tracks on the upper side, of Ornithopus gallinaceus. Two of them more distinct on the lower side.

28. Two leaves of reddish shale; one of them with two tracks of Plectropterna gracilis; the other has one of the same. Wethersfield.

29. Reddish shale, with two tracks of Platypterna Deaniana, showing the length of the step. Wethersfield.

30. Two leaves of red shale, with tracks of Argozoum pari-digitatum. Wethersfield.

31. Red shale, with three tracks of Triænopus leptodactylus. A calcigrade impression—a distinct hind toe coming out at the end of the heel. Wethersfield.

32. Red shale, with two tracks of Triænopus leptodactylus. Wethersfield.

33. The same—one track with narrow heel.

34. The same—one track with broad heel and apparently a fourth toe. E. H. remarks on this specimen: "I do not think I understand this species; probably several species are embraced in it." In 1849 it was subdivided, but the two were united subsequently into one.

35. Four tracks of Triænopus leptodactylus; one with a long heel and apparently a fourth toe near the end; but it belongs to another track.

36. Three tracks of Triænopus leptodactylus. A long heel with knob at the end. Wethersfield.

37. Red shale, showing tracks of Plesiornis æqualipes. Wethersfield Cove.

38, 39, 40. Red shale, with four tracks of Platypterna tenuis. Wethersfield.

41. Shale, with one track of Ornithopus gallinaceus. Chicopee, near Cabotville.

42. Red shale, with four tracks in relief of Brontozoum Sillimanium. Wethersfield.

43. Single track of Grallator formosus, on red shale. Wethersfield.

44. Single distinct track of Ornithopus gallinaceus, on red shale. Wethersfield.

45. Red shale, with two tracks of Anomœpus gracillimus, five of Anisopus gracilis, and rain-marks, all in relief. Turner's Falls.

46. Dark shale, in two leaves, with three tracks of Harpagopus dubius. South Hadley Canal.

47. Five tracks in a row of Triænopus leptodactylus, and one at least reversed. Red shale. Wethersfield.

48. One track of Brontozoum exsertum with two nodules, perhaps coprolites. Turner's Falls.

49. Single track, perhaps of Ancyropus heteroclitus. Turner's Falls.

50. Red shale, with seven hind and one fore feet impressions of Orthodactylus intro-vergens, in two rows. Turner's Falls. Type of species. Ichnology, Plate LI., fig. 1.

51. Single track of Brontozoum approximatum, and another of B. Sillimanium upon it. Cannot say which was impressed first. A good example to show that one track often does not obliterate another. Turner's Falls.

52 to 55. Potsdam sandstone, with tracks and trails of Protichnites, from Beauharnois, C. E. As many as sixty-five indentations, with ripple-marks.

56. Three leaves of red sandstone, with single track of Tridentipes elegans, the middle toe extending through the whole. The hind toe shows only at one opening. Turner's Falls.

57. Two leaves of red shale, with hind and fore foot of Anomœpus intermedius. Turner's Falls. 1863.

58, 59. Two tracks of Brontozoum divaricatum. Turner's Falls.

60. Shale, with ten tracks of Anisopus gracilior, with trails of Bisulcus undulatus. Lily Pond, Turner's Falls. 1863.

61. Red sandstone, showing single track of Brontozoum Sillimanium, with distinct phalanges and claws. Turner's Falls.

62. Two slabs outside the case, of Batrachoides nidificans. South Hadley Falls.

63. Single track of Brontozoum minusculum. Turner's Falls.

Total number of tracks in this Case, 207.

Case No. 33.

1. Micaceous sandstone, with row of four tracks of Argozoum pari-digitatum. Turner's Falls.
2. Red micaceous sandstone, with single track of Tridentipes elegans (?), very small. Marsh's quarry, Montague.
3. Single poor track of Tridentipes elegans. Turner's Falls.
4. Single track of Argozoum pari-digitatum, on gray shale. Below Turner's Falls.
5. Gray micaceous sandstone, with two tracks of Ornithopus gallinaceus. Horse Race, Gill.
6. Single track Selenichnus (?) falcatus. Turner's Falls.
7. Two tracks of Tridentipes elegantior, somewhat doubtful. Turner's Falls.
8. Single track, wanting in the outer toe, of Brontozoum divaricatum. Below Smith's Ferry, Northampton.
9. Similar to No. 8.
10. Red shale, with three tracks of Platypterna varica, a trail of Cunicularius retrahens, and one of Argozoum pari-digitatum.
11. Red shale, with one track of Stenodactylus curvatus. Turner's Falls.
12. One small track of Tridentipes elegans, showing the heel brush. Horse Race.
13. One track, on gray shale, of hind foot of Macropterna vulgaris. Horse Race.
14. Same, from Turner's Falls.
15. Same, showing the long heel. Below Turner's Falls.
16. Red shale, with one digitigrade track of Macropterna vulgaris. Wethersfield.
17. Gray sandstone, with a poor track of Anisopus gracilis. Northampton (?).
18. Hind foot of Corvipes lacertoideus. Turner's Falls.
19. Hind and fore feet (indistinct) of Anisopus Deweyanus. Turner's Falls.
20. Three tracks, probably of Stenodactylus curvatus. Turner's Falls.
21. Two tracks of Stenodactylus curvatus. Turner's Falls.
22. Two leaves of brown shale, with tracks of Plectropterna minitans or P. gracilis. Wethersfield.
23. Three leaves of the same shale, showing two tracks passing through them, all so nearly together that they seem on some layers to be only one track. "This case is described in the Ichnology, pages 30, 109, and exhibited on Plate XIX., figs. 10, 11, and 12. By a slip, I have stated on page 109, that the fore foot of P. minitans had not been found, when both are shown on these figures; but which is the hind and which the fore foot, I am in doubt, though judging from other cases, the rear track shows the hind foot. They seem very much alike, and hence do not correspond with P. gracilis as to the front foot. I think these specimens are probably neither P. minitans nor P. gracilis, and very likely of a different genus." E. H.'s notes.

24. Single track of same species, going through three layers. Three tracks and four pieces. Wethersfield.

25. One track of the same. Wethersfield.

26. Red shale, with two hind tracks and one fore track of Plectropterna gracilis, and a row of three hind and one front track of Corvipes lacertoideus; also one track of Brontozoum validum. Turner's Falls.

27. Shale, with three hind tracks and one front of Corvipes lacertoideus, with single hind and fore feet of Exocampe ornata. Turner's Falls.

28. Slab, with fifteen tracks of Anisopus gracilis. Turner's Falls.

29. Two leaves of gray shale with two rows of five tracks of Lagunculipes latens, seen best in relief; also one track of Tridentipes elegans. Turner's Falls. Ichnology, Plate XLV., fig. 4.

30. Shale, with a row of eight tracks of Macropterna vulgaris. Turner's Falls.

31. Row of six tracks of Macropterna vulgaris. Turner's Falls.

32. Three tracks of the same. Wethersfield.

33. Four tracks of the same. One shows the long heel finely, and all show upon the under side of the slab. Wethersfield.

34. Track of doubtful character, showing the filling in. In two slabs. Turner's Falls.

35. Slab of gray shale, with rows of four hind and two front tracks of Tarsodactylus caudatus, with traces of the claws. There is one straight trail near the tracks, made neither by the claws nor tail, being apparently a plant. Specimen shows fine example of Halysichnus laqueatus—made up of twenty parts or separate impressions. Turner's Falls.

36. Shale, with several paths of Cunicularius retrahens, and one track of Brontozoum Sillimanium. On back side are several branches of coniferous plants, two unknown tracks and rain-marks. Lunate impressions are connected with the paths of the Cunicularius, reminding one of the genus Lunula. Turner's Falls.

37. Shale, with ten tracks, both hind and front, of Apatichnus bellus, a row of four tracks of Anisopus gracilis, and fifteen tracks of Grammepus erismatus. Turner's Falls.

38. One track of Platypterna angusta. Turner's Falls.

39 to 43. Five tracks of the same.

44. Grallator cursorius. Turner's Falls.

45, 46. Plectropterna lineans. Turner's Falls.

47. Four tracks of Shepardia palmipes. Turner's Falls.

48. Two tracks of Anisopus gracilis. Turner's Falls.

49. Apatichnus bellus. Turner's Falls.

50. Apatichnus circumagens, hind and fore foot; also Cunicularius retrahens. Turner's Falls.

51. Single track of Brontozoum divaricatum. Northampton, on railroad.

52. Single track of Brontozoum divaricatum. Northampton, on railroad. Counterpart of No. 51.

53. Three tracks of Exocampe ornata (?). Below the dam at Turner's Falls.

54. Single track of Brontozoum exsertum. Turner's Falls.

55. Row of eight tracks in relief of Anisopus gracilior. Turner's Falls.

56. Single track in relief (type of species,) of Brontozoum approximatum. Turner's Falls. 1863. Counterpart of No. $\frac{54}{10}$.

57. Trails of Climacodichnus corrugatus. Turner's Falls. 1863.

58. Single track of Brontozoum validum. Turner's Falls. 1863.

59. Casts of reptilian impressions of the Carboniferous formation, from Horton's Bluff, N. S. Presented by Sir W. E. Logan to Prof. Hitchcock, in 1864.

Total number of tracks in this Case, 215.

Case No. 34.

1. Shows the ridge of mud in front of track of Tridentipes ingens. "An elephant would not raise a higher mound." Horse Race, Gill.

2. Single track of Brontozoum divaricatum. Turner's Falls.

3. Micaceous sandstone, with one row of three and another of two tracks of Argozoum paridigitatum. Compare with No. $\frac{9}{12}$. Turner's Falls.

4. One track of Brontozoum Sillimanium. Turner's Falls.

5. One track of Brontozoum validum. Turner's Falls.

6. Brontozoum approximatum. Turner's Falls.

7. Red Wethersfield shale. Two tracks of Brontozoum Sillimanium on upper side, with four or five on back side.

8. Plectropterna gracilis, on micaceous sandstone. Three hind feet, four fore feet and a tail trace. It seems as if a fore foot had been put down twice before the hind foot was moved. Turner's Falls.

9. Two hind and two fore feet of Plectropterna gracilis. Turner's Falls. Ichnology, Plate XLVIII., fig. 2.

10. Single hind foot impression of Plectropterna minitans. On shale. Cabotville.

11. Four tracks, at least, of Plectropterna minitans. Chicopee Falls.

12, 13. Single tracks of the same. Chicopee Falls.

14. Two tracks of Plectropterna minitans, on micaceous sandstone. Heels long. Toes of a third track visible. On back side are two tracks of Argozoum dispari-digitatum. Turner's Falls (?).

15. Two tracks of Brontozoum tuberatum, and one of B. Sillimanium, on upper side. On other side, four hind feet and one front, of Plectropterna gracilis. Turner's Falls.

16. One track of Brontozoum tuberatum. Turner's Falls.

17, 18, 26 and 27. Black shale with tracks of Amblypus dextratus. Turner's Falls. Ichnology, Plate XLVIII., fig. 5.

19. Single impression of Anomœpus minimus. Turner's Falls.

20, 21, 22, and 37. Seven hind tracks and four front tracks of Corvipes lacertoideus.

23. One track of Exocampe ornata (?). Turner's Falls.

24. Unknown track on gray shale. Below Turner's Falls, Gill.

25. The same, four tracks.

26, 27. See No. 17.

28. Three tracks of Brontozoum validum. Turner's Falls.

29. One track of Brontozoum divaricatum. Turner's Falls.

30. Four hind tracks, and perhaps one front track of Plectropterna minitans (?). Wethersfield.

31. The same, on shale. Cabotville.

32. Three tracks of Ancyropus heteroclitus, and three of Plectropterna minitans. Wethersfield.

33. Book of five leaves of Ornithopus gallinaceus—track extending through every layer. Turner's Falls.

34. Book of two leaves, showing both feet of Apatichnus circumagens. Turner's Falls.

35. Single track of Plectropterna minitans, of great size. North bank, below Turner's Falls.

36. Book of two leaves, of tracks resembling Plectropterna gracilis. Hind foot shows a fourth toe in addition to the spur; and the front lateral toes less divaricate. Nov. Gen. (?). North bank, below Turner's Falls.

37. See No. 20.

38. Single track of Plectropterna minitans, on micaceous sandstone. Heel very long. Wethersfield. Ichnology, Plate LIX., fig. 2.

39. Two tracks of Tridentipes elegantior. Turner's Falls.

40. Thirteen or fourteen tracks of Anomœpus minor—seven of them of front foot. Heels of the hind feet more distinct than the toes. Presented to E. Hitchcock by Dr. James Deane. Turner's Falls.

41. Shale, with single tracks of Gigantitherium minus, Grallator cuneatus, and Anisopus gracilis. Turner's Falls.

42. Shale, with half a dozen tracks of Ancyropus heteroclitus in two rows, and two tracks of Plectropterna minitans. Wethersfield.

43. Shale, with two rows—three hind and four front feet—of Stenodactylus curvatus. Turner's Falls. No. $\frac{34}{30}$ of Ichnology, Plate XXXIV., fig. 3.

44. Shale, showing nineteen tracks—nine of front feet—of Cheirotheroides pilulatus. Turner's Falls. No. $\frac{34}{31}$, of Ichnology, Plate XXXVI., fig. 6.

Total number of tracks in this Case, 158.

Case No. 35.

1. Shale, with two tracks of Brontozoum validum, and two of Platypterna varica. Turner's Falls.
2. Shale, with two tracks of Brontozoum validum. Turner's Falls.
3. Micaceous sandstone, with one track of Brontozoum minusculum.
4. Shale, with one track of Brontozoum validum, and three of Platypterna varica. Turner's Falls.
5. Gray shale, with row of five tracks—three hind—of Exocampe arcta. Below dam, Turner's Falls.
6. Single track of Brontozoum tuberatum. Turner's Falls.
7. Single track of Brontozoum validum. Turner's Falls.
8. One track of Brontozoum exsertum, showing all the phalanges, with a row of three tracks of Exocampe arcta. Turner's Falls.
9. Four tracks of Brontozoum Sillimanium. Turner's Falls.
10. Nine tracks of Macropterna vulgaris. Turner's Falls.
11. Two tracks of Grallator cuneatus on upper side, and one of Brontozoum validum on lower side. Turner's Falls.
12. Two impressions of Grallator cursorius. Turner's Falls.
13. Shale, with three tracks of what in the Ichnology is called Platypterna gracillima. Ill-defined. Compare with No. $\frac{39}{68}$. Turner's Falls.
14. Shale, with four tracks of Platypterna varica. Rain-marks on reverse side. Turner's Falls.
15. Same as No. 14.
16. Same as No. 14; also one track of Brontozoum validum, and two of Anisopus gracilis.
17. Tridentipes uncus. Turner's Falls.
18. Four tracks of Platypterna varica, and one of Grallator cursorius. Turner's Falls.
19. Both feet of Anisopus gracilis. Turner's Falls.

20, 21, 22. Volume of three leaves, showing rather doubtful impressions of Isocampe strata. Turner's Falls.

23. Shale, with row of nine tracks of Macropterna gracilipes. Turner's Falls.

24. Two hind feet and one front foot impression of Exocampe arcta. Very fine. North bank, below Turner's Falls.

25. Single tracks of both feet of unknown animal, remarkable for the *pelleted* appearance of all the toes. Turner's Falls.

27. Six tracks of Macropterna vulgaris, on shale. Turner's Falls.
28. Ten tracks of the same.
29. Shale, with two tracks of Orthodactylus intro-vergens. Turner's Falls.
30. Two tracks of Plectropterna lineans. Below the dam, Turner's Falls.
31. Two tracks of Grallator cuneatus (?) with supposed Gas Pustules. Chicopee Falls.
32. Row of fourteen tracks of Macropterna vulgaris, toes very much curved. Second row of same, with four tracks. Ichnology, Plate XLVIII., fig. 7. Turner's Falls.
33. Shale, with nine tracks of Macropterna vulgaris, and two hundred of Acanthichnus cursorius. On under side, one of Brontozoum giganteum. Turner's Falls.
34, 35. Poor specimens of what may have come from Harpedactylus concameratus. Horse Race, Gill.
36. Supposed coprolites. Smith's Ferry.
37. Track of Brontozoum divaricatum. South Hadley, north part.
38. One broken track of Brontozoum exsertum. Turner's Falls.
39. One track of Ornithopus gallinaceus. Horse Race, Gill.
40. Shale, with unknown track. Durham, Connecticut.
41, 42. Tracks of Macropterna vulgaris, and Tridentipes uncus. Turner's Falls.
43. Impressions of both feet of Anisopus gracilis. Turner's Falls.
44. Platypterna gracillima. Turner's Falls.
45. P. gracillima. Lily Pond.
46. Two tracks of Platypterna gracillima.
47. Both feet of Apatichnus bellus.
48. Plesiornis pilulatus, two tracks. Turner's Falls.
50. Eight tracks of Apatichnus bellus. Turner's Falls.
51, 52. Two leaves of shale, with obscure, apparently undescribed track. Outside of one leaf, three tracks of Corvipes lacertoideus.

Total number of tracks in this Case, 387.

Case No. 36.

1. Coarse micaceous sandstone, with five tracks of Hoplichnus poledrus. Ferry at Turner's Falls. Ichnology, Plate XLVIII., fig. 9.
2, 3. Five tracks of the same, from same locality.
4. One track of Brontozoum validum (?), or of a web-footed animal allied to Hyphepus. Turner's Falls.
5. Brontozoum tuberatum. Turner's Falls.
6. Micaceous sandstone, with row (four hind and three front feet) of Apatichnus bellus, and tow tracks of Apatichnus (?) circumagens. South Hadley, north part.
7. Slab of gray shale, with tracks of Ornithopus gracilior, Triænopus leptodactylus, and probably other species. Below dam at Turner's Falls.
8, 9. Ptilichnus anomalus. Turner's Falls.
11. Micaceous sandstone, with fine row of Hexapodichnus magnus; sometimes showing the tracks of six feet, usually of only two on each side; 175 in all. Turner's Falls. Ichnology, Plate XXIX., fig. 7.
12, 13. Shale, with Ptilichnus anomalus. Turner's Falls. Ichnology, Plate XXV., figs. 1, 2.
14. Shale, with two trackways of Bifurculipes scolopendroideus, 58 tracks. Below the dam at Turner's Falls.
15. Shale, with fine trackway of Sphærapus magnus, sixty impressions. Turner's Falls. Ichnology, Plate LI., fig. 3.

16. Two leaves of shale, with row of five tracks of Platypterna digitigrada, and trackway—twenty tracks—of Hamipes didactylus. Ichnology, Plate LI., figs. 2, 4.

17. Shale, showing trackways of Bifurculipes elachistotatus (four rows of forty-eight tracks,) and of Copeza cruscularis (forty-three tracks.) Also a good impression of a coniferous plant. Lily Pond, Turner's Falls. Ichnology, Plate XXIX., fig. 4.

18. Shale, with trackway of forty-eight tracks of Copeza propinquata. Lily Pond.

19. Shale, with several rows of Acanthichnus cursorius; two of Copeza propinquata; one of Cochlichnus anguineus; one of Pterichnus centipes; and four tracks in a row, of Exocampe ornata. Track of Brontozoum Sillimanium on upper side. 410 tracks on this slab. Lily Pond. Ichnology, Plate XXVIII., fig. 1.

20. Shale, with three splendid examples of Cochlichnus anguineus. Lily Pond.

21. Shale, with five double rows of Acanthichnus cursorius; nine tracks of Macropterna, and impressions of coniferous plant with supposed seeds. 196 tracks. Lily Pond. See Ichnology, Plate XXXI., fig. 1.

22. Gray sandstone, with numerous trails of Unisulcus intermedius,—as many as sixty. Horse Race, Gill.

23. Shale, with perhaps fifty trails of Unisulcus minutus. Horse Race, Gill.

24. Fine shale, with three indistinct double rows of Acanthichnus, and one of Hexapodichnus horrens—about 100 tracks. Lily Pond.

25. Shale, with two double rows of Conopsoides larvalis—forty-two tracks. Lily Pond. Ichnology, Plate XXIX., fig. 6.

26. Shale, with trackway of ninety tracks of Copeza propinquata. Lily Pond. Ichnology, Plate XXIX., fig. 3.

27. Shale, with five rows of two hundred tracks of Acanthichnus cursorius, A. saltatorius, and Pterichnus centipes. Lily Pond.

28. Shale, with curved trackway of forty-three tracks of Bifurculipes laqueatus. Lily Pond.

29. Shale, with two rows of eighty-two tracks of Acanthichnus cursorius. Lily Pond.

30. Shale, with trackway of sixty-two tracks of Acanthichnus cursorius. Lily Pond.

31. Shale, with trackway of forty-eight tracks of Acanthichnus saltatorius. Lily Pond.

32. Book of two leaves, showing a trackway of thirty tracks of Acanthichnus cursorius, both depressed and in relief. Lily Pond.

33. Shale, with three tracks of Brontozoum validum, three trackways of Bifurculipes laqueatus, and one of Hexapodichnus horrens. In all, 266 tracks. Lily Pond. Ichnology, Plate XXX., fig. 1.

34. Shale, with one trackway of sixty-two tracks of Acanthichnus saltatorius, and at least one hundred rather scattered tracks of the same genus, with a few impressions of a coniferous plant. Lily Pond.

35. Trackway of Bifurculipes, and a delicate one of Acanthichnus trilinearis. In all, ninety-six tracks. Lily Pond.

36. Shale, with trackway of one hundred impressions of Sphærapus larvalis. Lily Pond.

37. Shale, with trackway of one hundred and five tracks of Copeza triremis, and sixteen of Grammepus erismatus. Lily Pond.

38. Shale, with trackway of ninety tracks of Ampelichnus sulcatus, and very delicate ripple-marks. Lily Pond.

39. Shale, with trackway of fifty-seven tracks of Grammepus erismatus. Lily Pond.

40. Shale, with trail of Cochlichnus anguineus. Lily Pond.

41. Shale, with trackway of Bifurculipes scolopendroideus. Below the dam at Turner's Falls.

42. Red shale, with hind and fore feet of Plectropterna lineans. Wethersfield.

43. Shale, with four tracks of Saltator bipedatus and two of Exocampe ornata. Below the dam at Turner's Falls. Ichnology, Plate LI., fig. 7.

44. Shale, with trail of Unisulcus intermedius. Turner's Falls.

45. Trackway of fifty-nine tracks of Copeza punctata, of Acanthichnus cursorius, and Lunula obscura (?). Lily Pond.

46. Interesting specimens of trail of Cochlea Archimedea. Lily Pond.

47. Trackway of forty-two tracks of Pterichnus centipes. Lily Pond.

48. Trackway of thirty-seven tracks of Bifurculipes laqueatus. Lily Pond.

49. Trackway of Cochlea Archimedea. Lily Pond. Ichnology, Plate XLIX., fig. 7.

50. Delicate ripple marks, formerly referred to Ptilichnus pectinatus. Lily Pond. Ichnology, Plate XXV., fig. 9.

51. Shale, with trackway of sixty-four tracks of Bifurculipes. A short second trackway of the same, with numerous seeds (?). Lily Pond.

52. Very perfect specimen of the hind and front feet of Macropterna vulgaris. Lily Pond.

Total number of tracks in this Case, 3,023.

Case No. 37.

1. Track of Tridentipes ingens. Horse Race, Gill.

2. Single track of Brontozoum exsertum. Turner's Falls.

3. Single track of Brontozoum divaricatum. Horse Race, Gill.

4. Brontozoum Sillimanium. Turner's Falls.

5. Brontozoum validum. Turner's Falls.

6. Brontozoum validum, in relief. Turner's Falls.

7, 8. Brontozoum validum, depressed and in relief. Turner's Falls.

9, 10. Two leaves of Chimæra Barratti and Brontozoum Sillimanium, with numerous fine rain-marks. Turner's Falls. Ichnology, Plate LIX., fig. 4.

11, 12. Slab with about seventy tracks of Anisopus gracilis, and ripple-marks. Horse Race, Gill.

13, 14. Single tracks of Brontozoum validum. Turner's Falls.

15. Single track of Brontozoum tuberatum.

16, 17. Single tracks of Argozoum dispari-digitatum. Wethersfield.

18. Three tracks of Anomœpus gracillimus, made after the accompanying rain-marks. Turner's Falls.

19, 20. Argozoum dispari-digitatum. From Turner's Falls and Wethersfield.

21. Red shale, with sixteen tracks of Anisopus gracilis, and ripple-marks. Horse Race, Gill.

22. Red shale, with tracks of Argozoum dispari-digitatum (?) and Platypterna Deaniana. Wethersfield.

23. Shale, with about sixty tracks of Anisopus gracilis, and ripple-marks. Horse Race, Gill.

24. Two slabs, showing Platypterna Deaniana (?). Remarkable for the slide forward seen in the lower track.

25. Shale, with two tracks of Anomœpus minimus, part of one of Anisopus gracilis, one of Brontozoum Sillimanium, and the trails of Cunicularius retrahens, probably. Lily Pond.

26. Red shale, with two impressions of Platypterna Deaniana. Wethersfield Cove.

27. Brontozoum divaricatum. Turner's Falls.

28, 29. Shale, with rain-marks, two hind tracks of Anomœpus minor, part of the fore foot, and one of Plesiornis quadrupes. Lily Pond.

30. Annelid tracks, from Lower Silurian of Waterville, Maine.

Total number of tracks in this Case, 182.

Case No. 38.

1. Shale, with one track of Grallator formosus, and one of G. cuneatus. Chicopee Falls.

2. One track of Grallator formosus. Northampton.

3. One track of Brontozoum validum. Turner's Falls.

4. One track of Brontozoum giganteum. Turner's Falls.

5, 6. Two leaves of Batrachoides nidificans, below the layer where the nests were made. South Hadley Falls.

7. Batrachoides nidificans, on successive layers. South Hadley Falls.

8. 9. Nests of Tadpoles (Rana palustris, Leconte,) in mud. From "Tadpole City," in Hadley. Ichnology, page 121, Plate L., figs. 3, 4.

10, 11, 12. Concretions in limerock of Niagara Group, Lockport, New York, referred in Ichnology (Plate L., fig. 2,) to Batrachoides antiquior.

13. Slab of red sandstone, showing Batrachoides nidificans, occupying the furrows of ripple-marks, just as is done by modern tadpoles. South Hadley Falls.

14, 15. Elegant leaves, 2° 8′ × 2° 1′, of sandstone, marked by nests of Batrachoides nidificans. South Hadley Falls. Ichnology, Plate L., fig. 1.

16. Slab, 2° 6′ × 2°, with sixty tracks of Anisopus gracilis, and ripple-marks. Horse Race, Gill. Ichnology, Plate XLIII., fig. 3.

17 to 21. Nests of Batrachoides nidificans, in the furrows of ripple-marks. South Hadley Falls.

22. Batrachoides nidificans, on different layers. South Hadley Falls.

23. Mud-holes, slightly resembling the Batrachoides. Turner's Falls. Presented by C. H. Hitchcock.

24, 25. Nondescript tracks, like Brontozoa. 1863. Turner's Falls.

Total number of tracks in this Case, exclusive of tadpole nests, 67.

Case No. 39.

1. Track of Brontozoum exsertum. Turner's Falls.

2. Shale, with track of Grallator formosus (?). Chicopee Falls.

3. Rain-drop impressions. Turner's Falls.

4. Four tracks of Platypterna gracillima—a doubtful species. Turner's Falls.

5. The same, four tracks.

6. Six tracks of Xiphopeza triplex—probably the same with Nos. 4 and 5. Turner's Falls.

7. Two tracks of Stenodactylus curvatus. Turner's Falls.

8. Three tracks of Xiphopeza triplex. Turner's Falls, below the dam.

9. Four tracks of Anisopus Deweyanus. Turner's Falls.

10, 11. Two leaves, showing a Harpedactylus—but below where the animal trod. Wethersfield, Connecticut.

12. A depression in talcose schist, somewhat resembling a footmark. Western Massachusetts.

13 to 18. Different forms of Coprolites, from the hard grit at Chicopee Falls. No. 18 is from Northampton and may not be a coprolite.

19 to 24 and 24½. Ripple-marks from the Connecticut Valley, except the first three, which are from the Lower Silurian sandstone on the south shore of Lake Superior.

25 to 65. Impressions and casts of rain-drops, principally from Turner's Falls. No. 44 is a brick marked by rain. Nos. 58 and 60 are small ripple-marks. Nos. 33, 34 and 35, are mud-holes, difficult to explain. Nos. 31, 34, 54, 63, in Ichnology, Plate LVI., figs. 7, 5, 8, 6.

10

66, 67. Coprolites from the Lias, near Bristol, in England. One of them has been polished.

68. Two tracks of Macropterna divaricans (?). Turner's Falls.

69. Three tracks of Exocampe ornata. Turner's Falls.

70. Seven tracks of Macropterna vulgaris, with impressions of an aroid plant. Turner's Falls.

71. Four tracks of Exocampe ornata. Turner's Falls.

72, 73, 74. Echinoderms (?). Turner's Falls.

75. Septaria. Chicopee Falls.

76. Singular and unknown impressions—probably of animal origin. From Wethersfield Cove, Connecticut.

77. Row of fourteen tracks of Macropterna gracilipes. Turner's Falls. Ichnology, Plate LI., fig. 6; XXXIV., fig. 1.

78. Seven tracks of the same. Turner's Falls.

79. Fine row of twenty-eight tracks of Macropterna vulgaris. Turner's Falls. Ichnology, Plate XLIX, fig. 3.

80 to 86. Marks of rain-drops. Turner's Falls.

Total number of tracks in this Case, 92.

Case No. 40.

1. Shale, indurated by proximity to trap, with ten tracks of Exocampe arcta, and numerous fine rain-drops. Turner's Falls, below the dam.

2. Cast of the foot of a wild turkey.

3. Plant (?) or effect of water upon shale. Turner's Falls.

4. Single track of Brontozoum exsertum. Turner's Falls, Montague shore.

5. Track of Brontozoum divaricatum. Northampton.

6. Single track of Tridentipes uncus. Turner's Falls.

7. Cast of five tracks of Paleozoic reptiles. From Pennsylvania. Presented by Prof. Jeffries Wyman.

8. Trails and tracks of Helcura anguinea, nine in all. Traces of the toes and tail. Turner's Falls, north bank, below dam.

9. Macropterna vulgaris. Turner's Falls.

10. Both feet of Xiphopeza triplex. Turner's Falls.

11. Three tracks of Arachnichnus dehiscens. Turner's Falls.

12. One good track of A. dehiscens. Turner's Falls.

13. Four tracks of A. dehiscens. Turner's Falls.

14. Unknown track. Turner's Falls, north bank, below dam.

15. Claw and tail traces, and about ten tracks of Helcura anguinea. Turner's Falls, north bank, below dam.

16. Tracks of a modern salamander. Prepared and presented by Roswell Field. Ichnology, Plate LV., fig. 3.

17. Cast of a crow's foot.

18. Impressions of rain-drops on alluvial clay. Connecticut River, Hadley.

19. Exocampe arcta (?). Turner's Falls.

20. Two impressions of a boy's foot, on alluvial clay, showing finely the striæ upon the skin. Hadley.

21. One track of Macropterna vulgaris. Turner's Falls.

22. Impression of boy's foot, showing striæ of two bird's feet, and of rain-drops, on clay. Hadley. Ichnology, Plate XXXII., fig. 1.

23. Nine impressions of bird's feet (crow) with rain-drops, on clay. Hadley.

24. Impressions of boy's foot, of seven bird's feet, and rain-drops, on clay. The boy's foot slipped. The papillæ of the crow's foot, as well as the phalangeal protuberances, are well exhibited. The boy's heel trod on a crow's track, yet did not obliterate it. Hadley.

25. Two tracks of a bird, probably a crow, standing still, showing long hind toe and claw, on clay. Hadley. Ichnology, Plate LIV., fig. 4.

26. Single impression of crow, and of rain-drops, on clay. Hadley.

27. Tracks of a snipe, Totanus macularius, on black mud spread over shale. From Horse Race, Gill. A specimen interesting as having convinced some naturalists in the early history of Ichnology of the verity of the ichnites. Described in the "London Literary Gazette."

28, 29. Casts of the feet of Rhea Americana, the South American ostrich. Presented by Prof. Jeffries Wyman. Ichnology, Plate LV., fig. 1.

30. Two double trails of unknown living animal—possibly a young tortoise—whose carapace impressed the soft clay; also gas pustules. Hadley. Ichnology, Plate LV., fig. 2.

31, 32, 33. Five tracks of common snipe, on clay. Hadley.

34. Eight tracks of common snipe, on clay. The bird stopped occasionally on his march, making his tracks irregularly. Hadley. Ichnology, Plate LIV., fig. 1.

35. Four tracks of the snipe, two of which are in relief, and obtained by splitting off a layer of clay; thus completely illustrating the mode of formation of the fossil foot-marks on clay. Hadley.

36. Single impression of an unknown bird, on clay. Hadley.

37. Track in relief of a thick-toed bird, on clay. Hadley.

38. Hind feet of a frog, probably, on clay. Hadley.

39. Two tracks of fore feet of a frog, and the trail of an annelid, on clay. Hadley.

40. Six tracks of a frog, and fifty of an annelid, on clay. Hadley. Ichnology, Plate LV., fig. 4.

41. Two tracks of a snipe, and annelid trail, on clay. Hadley.

42. Unknown track, on clay. Hadley.

43. Rain-marks, on clay. Hadley.

44. Row of six impressions of a snipe and of rain-drops, on clay. Hadley. Ichnology, Plate LIV., fig. 2; XXXI., fig. 2.

45, 46. Snipe's tracks, on clay. Hadley.

47. Rain-marks, on clay. Hadley.

48. The hind and front feet, with the marks of the abdomen of a frog as he rested on the ground; also twenty-six small trifid tracks in two rows, very wide apart, for a bird, on clay. Hadley. Ichnology, Plate LIV., fig. 3; XXXII., fig. 2.

49. Minute traces, perhaps of an annelid, on clay. Hadley.

50. Plaster cast of the foot of a hen.

51. Cast of the foot and spur of the domestic cock.

52. Cast of the foot of a domestic turkey.

53, 54. Casts of tracks of both feet of a large tortoise.

55. Six impressions of a snipe, and trails of annelids, on clay. Hadley.

56. Three impressions of a snipe, and rain-marks, on clay. Hadley.

57. Track of a dog, on clay. Hadley.

58. Cast of Ptilichnus anomalus.

59. Cast of tracks of Paleozoic reptile. From Pennsylvania. Presented by Prof. Jeffries Wyman.

60. Book of two leaves, showing one track of Hyphepus Fieldi; one of Grallator cuneatus, and two or three of Anisopus gracilis. Turner's Falls.

61. Track of foot and tail of Hyphepus Fieldi. The hind toe shows well. Turner's Falls.
62. Both feet of Isocampe strata. Turner's Falls.
63. Eight tracks of Anisopus gracilis (?). Turner's Falls.
64. Single track of Macropterna divaricans. Horse Race.
65, 66. Rain-marks. Turner's Falls.
67. Cast of foot of domestic turkey.
68. Two casts of foot of the coot—Botaurus lentiginosus.
69. Fourteen impressions of Arachnichnus dehiscens, and one of Tridentipes elegans. Turner's Falls.
70. Annelid impressions. New York State. J. Avery, donor.
71. Crustacean impressions, Clinton Group. Columbia, New York.

Total number of tracks in this Case, 322.

The specimens of clay from Hadley, were obtained chiefly by C. H. Hitchcock, in 1852 and 1853, and by him presented to the Cabinet. Described in American Journal of Science and Arts, N. S., Vol. XIX., p. 391. See Ichnology, page 170, and Plates XXXI., XXXII.

Case No. 41.

1. Twelve tracks of Macropterna vulgaris. Below the dam at Turner's Falls.
2, 3. Four tracks of Macropterna vulgaris, from the same locality.
4. Four leaves of shale, showing part of the track of Ornithopus gallinaceus, extending through them all. Wethersfield.
5. Four tracks on three leaves of Plectropterna minitans. Probably Wethersfield.
7. Single track of Grallator cuneatus. South Hadley, two miles N. W. from the church.
8, 9. Three hind and two front feet of Plectropterna gracilis. Turner's Falls.
10. Two tracks of Corvipes lacertoideus. Horse Race, Gill.
11. One track of Brontozoum exsertum or B. validum. Turner's Falls.
12. Sixteen tracks of Macropterna vulgaris (?). Turner's Falls.
13. Twelve tracks of Exocampe arcta, and one of Arachnichnus (?). Rain-marks on reverse side.
14. Four tracks of Ornithopus gracilior. Turner's Falls.
15, 16. Single tracks of Brontozoum Sillimanium. Wethersfield.
17. Single track of Grallator cursorius. Wethersfield.
18. Single obscure track of Anomœpus gracillimus. Wethersfield.
19. Single track of Brontozoum Sillimanium. Wethersfield.
20. Fine row of six tracks of the hind foot of Exocampe arcta. Turner's Falls. Ichnology, Plate XLIX., fig. 5.
21. Argozoum dispari-digitatum. Wethersfield Cove.
22. Two tracks of Anomœpus gracillimus. Wethersfield.
23. Single track of Brontozoum validum or Grallator formosus. The animal was changing his course. Chicopee Falls.
24. Two tracks of B. Sillimanium (?), and two minute unknown tracks. Wethersfield.
25. Row of eight tracks of both feet of Macropterna divaricans. Turner's Falls. Ichnology, Plate XLVIII., fig. 3.
26. Two rows of seven tracks of both feet of Xiphopeza triplex. Turner's Falls.
27. Twenty-five tracks of Macropterna vulgaris. Turner's Falls.
28, 29. Rows of eleven and ten tracks of Macropterna vulgaris. Turner's Falls.
30, 31, 32, 35, 36. Single tracks of Plectropterna minitans. Wethersfield.
33. Single track, showing well the phalanges of Brontozoum exsertum. Below the dam at Turner's Falls.

34. Two tracks of Anomœpus gracillimus, and one of Grallator cuneatus. Wethersfield.
37. Single track of Argozoum pari-digitatum. Marsh's quarry, Montague.
38. Three tracks of Grallator cuneatus. Wethersfield.
39. Fine row of ten tracks of Exocampe ornata. Below the dam at Turner's Falls. Ichnology, Plate XLVIII., fig. 6.
40, 41. Two leaves of ten tracks of Exocampe ornata. Turner's Falls.
42. Both feet of Macropterna divaricans. Turner's Falls.
43. Single track of Brontozoum exsertum. Northampton.
44. Probably vegetable impressions. Wethersfield.
45. Two tracks of Macropterna vulgaris. Wethersfield.
46. One track of Plectropterna minitans. Wethersfield.
47. Two tracks of Ornithopus gracilior. Turner's Falls (?).
48, 49. One track of Ornithopus gallinaceus. Horse Race.
50. Row of six tracks of Ancyropus heteroclitus, on two pieces. Wethersfield.
50½. Three tracks of the same.
51. Six tracks of Anisopus Deweyanus or A. gracilis, with imperfect rain-marks. Turner's Falls. Presented by Dr. James Deane, of Greenfield.
52. Nine tracks of both feet of Antipus flexiloquus; also on a deeper layer, two trails of Cunicularius retrahens; and on under side one hind foot of Anomœpus minor, and another trail of Cunicularius. Turner's Falls.
53. Five tracks of both feet of Xiphopeza triplex. Below the dam at Turner's Falls.
54. Tracks of both feet of Harpedactylus gracilis. Below the dam at Turner's Falls.

The number of tracks in Case No. 41, upon the specimens thus far described, is 220.

The specimens in this Case, Nos. 55 to 108, are tracks and trails of Crustaceans and Annelids from the Clinton Group of the Upper Silurian in Columbia, N. Y. They were obtained by C. H. Hitchcock in 1863, but have never been studied, and therefore are only mentioned here in general.

109. Two specimens, showing the fore foot of Megadactylus polyzelus, *E. Hk. fil.* Springfield. Supplement, Plate IX., fig. 6.
110. Rib of the same.
111. Metatarsal bone.
112. Head of humerus.
113. Metatarsal bone.
114. Single claw.
115. Part of femur, showing the third trochanter.
116, 117. Vertebræ.
118. Metatarsus; all of Megadactylus polyzelus. There are other osseous fragments of the same in the Case, not numbered.

All the specimens in the remaining Cases are from Turner's Falls, generally from Lily Pond, except those specially designated, and were obtained in two lots, in 1857 and 1862.

Wall No. 42.

Nos. 42 to 48, are in the second side room as you advance from the front door along the platform. No. 42 is upon the south side of the room, west of the door.

1. Slab of fine sandstone, 3° 9′ × 9′, showing a depressed row of tracks of the hind feet of Plectropterna angusta; also a larger unknown track.
2. Slab of gray shale, 3° 5′ × 9′, showing a row of impressions of hind feet of Plectropterna lineans; a row of twelve tracks of Exocampe ornata, and three tracks of Anisopus gracilis.

3. Slab of dark shale, 4° 8′ × 7′ showing a long row of twelve impressions of Anisopus gracilis, with four tracks of the same, upon another row crossing the first. The finest specimens of this ichnite in the whole Cabinet.

4. Slab like No. 3, 3° 10′ × 6′, with a row of sixteen impressions of A. gracilis, with single tracks of Apatichnus circumagens and Anomœpus minor.

5. Slab of hard shale, 4° 9′ × 1° 3′, showing every kind of impression made by Tarsodactylus caudatus, viz.: a row on each side of the trackway, with marks of the toes and tail trailing on the ground. The finest slab of this species in the Cabinet. Also nine imperfect tracks of a Brontozoum, and shrinkage cracks. Ichnology, Plate XXXVI., fig. 2.

6. Slab of red sandstone, 4° 2′ × 10′, showing a row of fifteen depressed tracks of hind feet and one fore foot of Selenichnus falcatus with a very distinct tail trace; also a row of impressions of S. breviusculus, with obscure plants and rain-marks. Ichnology, Plate LX., fig. 8.

7. The same as No. 6, in relief, 3° 6′ × 2° 2′. These two slabs are the type of the S. falcatus.

Total number of tracks on this Wall, 138.

Wall No. 43.

1. Slab of dark shale, 2° 8′ × 1° 8′, showing single impressions of Brontozoum giganteum and B. approximatum, the latter with claws almost like pellets.

2. Similar slab, 5° 7′ × 1° 5′, with a rough surface, showing two fine tracks of B. giganteum.

3. Sandstone, 15′ × 13′, with single impression of Brontozoum minusculum.

4. Large slab, 9° 8′ × 2°, with a fine row of five impressions of a large Brontozoum validum; four rows and seven insulated tracks of Grallator cuneatus; single impressions of B. minusculum and B. divaricatum; with hundreds of small impressions, resembling Saltator or Sphærapus.

5. Slab, 2° 5′ × 1° 2′, showing four single impressions of Brontozoum validum, and one of Grallator formosus.

6. Slab, 3° 1′ × 2° 5′, with two impressions of Brontozoum approximatum, two of B. Sillimanium, and two of Grallator cursorius.

7. Slab, 2° 3′ × 2°, with one impression of Brontozoum validum, and one of B. minusculum. The former has what looks like a fourth toe, and the two are associated together in a manner suggestive of the hind and fore feet of a gigantic quadruped.

Total number of tracks on this Wall, 40.

Wall No. 44.

1. Slab, 1° 10′ × 1° 6′, with single impression of Brontozoum giganteum. Turner's Falls, north bank below the dam.

2. Slab of sandstone, 4° × 3°, with one impression of B. giganteum, one row of two tracks of Gigantitherium minus with tail trace, and impressions of Anomœpus curvatus; viz.: a row of five tracks, one of three, two of two, and a single one; also shrinkage cracks.

3. Slab, 1° 6′ × 1° 3′, with one impression of Brontozoum giganteum, with the claws of the inner and middle toes turned outward remarkably.

4. Single impression of Brontozoum minusculum.

5. Slab of red sandstone, 1° 7′ × 1° 2′, showing trails more or less fimbriated, of Annelidans or Crustaceans, from the Clinton Group of Upper Silurian rocks, Columbia, New York. Obtained by C. H. Hitchcock, in 1863. See Palæontology of New York, Vol. II.

7. Slab of dark sandstone, 3° 8′ × 2° 2′, with two rows of two and three tracks of Brontozoum Sillimanium; two rows of five and six, and four insulated tracks of Plesiornis quadrupes, and one row of four tracks and trails of Hyphepus Fieldi. Ferry above Turner's Falls.

8. Single impression of Brontozoum approximatum, with shrinkage cracks.

9. Slab, 4° × 2° 5′, showing one impression of Brontozoum approximatum, three of B. exsertum, and three of B. Sillimanium.

10. Beautiful slab, 3° 6′ × 3° 5′, suspended before the window, showing upon the west side, casts of rain-marks, and the finest example in the Cabinet (type) of Selenichnus breviusculus; a row of twenty-three tracks, and a strong tail trace. Ichnology, Plate LX., fig. 7. Upon the opposite side are mutitudinous impressions of Ænigmichnus multiformis, consisting of grooves and lines of punctures, more or less parallel to one another. In Ichnology referred to Ptilichnus typographus. Ferry at Turner's Falls.

At least 500 tracks on this Wall.

Wall No. 45.

1. Slab, 9° 2′ × 2° 6′, with two rows of three impressions each, of Brontozoum giganteum, so nearly coincident in direction, and the tracks so near together, that they might easily be supposed to be the hind and fore feet of one animal, like the Plesiornis. But the two rows obviously cross each other. Shows also six impressions of B. validum, five of B. Sillimanium, one of B. approximatum, and one of B. exsertum, trod upon deeply by B. giganteum, but not obliterated.

2. Shale, 8° × 1° 3′, with fine row of Brontozoum minusculum, showing the phalangeal impressions well, of the inner toes; three impressions of B. validum, two of B. Sillimanium and a few ripple-marks.

3. Similar slab, 5° 8′ × 2°, with two impressions of B. giganteum, three of B. validum, and one of Grallator cuneatus.

4. Shale, 2° 6′ × 2°, with two impressions of B. giganteum.

5. Fine shale, 1° 6′ × 5′, with one row of twelve and another of nine tracks of Anisopus gracilior.

6. Same rock, 1° 7′ × 9′, showing one row of fourteen tracks of Anisopus gracilior, and supposed flipper trails.

7. Red sandstone, 2° 2′ × 1° 6′, with numerous crustacean trails, from the Clinton Group of the Upper Silurian system. From Columbia, New York. Obtained by C. H. Hitchcock, in 1863.

8. Heavy slab in a case, 1° 7′ × 1° 7′, on small table, showing single impression of Brontozoum giganteum, the type specimen of the species as amended in the Supplement.

9. Similar slab, 1° 4′ × 1° 7′, with single impression of B. giganteum. Below dam at Turner's Falls.

10. Slab of dark sandstone, 3° 4′ × 1° 9′, showing very fine impressions of rain-drops. Ferry above Turner's Falls.

At least 150 tracks on this Wall.

Wall No. 46.

1. Reddish shale, 2° 8′ × 12′, with several rows of about thirty tracks of Anisopus gracilior, but obscure.

2. The same, 2° 3′ × 9′, with about twenty tracks.

3. The same, 4° 7′ × 1° 3′, with seventy-four tracks of Anisopus gracilior. Two rows start near the bottom and come into one line part way up. "Flipper trails" and shrinkage cracks common.

4. Shale, 1° 11′ × 1° 3′, with a row of six tracks of Shepardia palmipes and shrinkage cracks.

5. Slab of shale, 2° 7′ × 12′, with fine row of ten tracks of Anisopus gracilis, and three other tracks of same, alternating.

6. Slab, sixteen inches square, with one row of six fine large tracks of Anisopus gracilis; another of four tracks, and two single ones.

7. Shale, 2° × 13′, with one row of ten and another of four tracks of Anisopus gracilis.

8. Shale, 15′ × 9′, with a row of seven tracks of Arachnichnus dehiscens and shrinkage cracks.

9. Slab, 1° 7′ × 9′, with eleven tracks of Arachnichnus (?).

10. Slab of shale, 1° 10′ × 8′, with row of six tracks of Anisopus gracilis. Remarkable for length of step—eleven inches—double that given in the Ichnology.

11. Shale, 2° × 9′, with row of ten rather indistinct tracks of Anisopus gracilis, and one of Grallator cursorius (?).

12. Shale, 3° 7′ × 1° 6′, with two rows of rather indistinct tracks of Anisopus gracilis, twenty-one in number.

13. Slab, 2° × 10′, with seven hind and seven front feet of Arachnichnus (?), and shrinkage cracks.

14. Sandstone, 3° 3′ × 10′, with row of sixteen tracks of some unknown animal.

Total number of tracks on this Wall, 247.

Table No. 47.

1, 2. Single impression of Brontozoum Sillimanium.

3. Single impression of Anomœpus minor.

4, 5. Single tracks of Ornithopus gracilior, from the north bank of Connecticut River, below Turner's Falls.

6. Gray shale, with one track of Ornithopus gracilior, and one probably of Plectropterna minitans. North bank, below Turner's Falls.

7. Seven tracks of Macropterna (?) vulgaris, with fine tail trace, sweeping to the right and left.

8. Single track of Apatichnus circumagens.

9. Single track of Tridentipes uncus.

10. Two tracks of Anisopus gracilis.

11. Remains of Palæphemera mediæva, *Dana*, an insect. Horse Race.

12. Two rows of Grammepus erismatus.

13. Trackway of Grammichnus Alpha.

14. Tracks of Grammepus erismatus.

15, 16. Marks of rain-drops.

17. Three impressions of Brontozoum Sillimanium.

18. Tracks of Grammepus erismatus.

19. Numerous specimens of Palæphemera mediæva. Horse Race.

20, 21, 22. Typical specimens of tracks of articulate animals named Climacodichnus corrugatus in Supplement. Ferry above Turner's Falls.

23, 24, 25. Single tracks of Brontozoum Sillimanium.

26. Twelve tracks of Anisopus gracilis.

27. Single toe of Argozoum Redfieldianum (?).

28. One track of Plesiornis pilulatus, and half a dozen of Exocampe arcta.

29. Palæphemera mediæva, *Dana*. Horse Race.

30. Two tracks in succession of Trihamus elegans. Type of the species. Figured in Supplement, Plate II., fig. 3.

31. One track of Plesiornis pilulatus, and ten of Antipus flexiloquus, two of them hind feet.

32 to 35. Seven tracks of Anisopus gracilis.

36. Palæphemera mediæva, *Dana.* Horse Race.
37. Five tracks (two fore feet,) referred to Arachnichnus dehiscens.
38, 39. Probably the same as No. 37.
40. Single track of Leptonyx lateralis. Typical specimen. Supplement, Plate V., fig. 3.
41, 42, 49, 60, 66, 69, 71. Probably Plectropterna, though the hind toe is wanting.
43. Echinoderm (?).
44. Single track, also a row of them, of Plesiornis pilulatus; an Exocampe, and an aroid plant.
45. Two tracks of Arachnichnus (?).
46. Four tracks of Anisopus gracilis, and seven trails of Unisulcus intermedius. Horse Race, Gill.
47. Two fine trails of Unisulcus minutus.
48. Track of Triænopus (?).
49. See No. 41.
50. Probably referrible to Arachnichnus.
51. Track of Leptonyx lateralis.
52. Track of Harpedactylus gracilior. North bank, below Turner's Falls.
53. A smoothed specimen of gray shale, showing two tracks of Macropterna vulgaris, one of Plectropterna minitans, and the hind and front feet of Harpedactylus crassus. Typical specimen of latter species. Supplement, Plate III., fig. 1.
54. Unknown tracks.
55. Track of Tridentipes uncus.
56. Track of Brontozoum Sillimanium.
57. Trail of Cochlichnus anguineus.
58, 59. Two tracks on each, of Plesiornis pilulatus—counterparts.
60. See No. 41.
61. Track of Plectropterna angusta.
62. Hind and front feet of Anisopus Deweyanus (?).
63. Two tracks of Brontozoum validum.
64. Three trackways of Acanthichnus cursorius.
65. One trackway of Acanthichnus cursorius.
66. See No. 41. North bank, below Turner's Falls.
67. Six impressions of Grammepus uniordinatus, and a probable hind impression of Selenichnus falcatus, figured in the Supplement, Plate II., fig. 7.
68. Four tracks of Anisopus gracilis.
69. See No. 41.
70. One row of two tracks of Macropterna divaricans; one of two slender toes and not very divaricate; and one of three tracks with four toes and heel. Also, Xiphopeza triplex.
71. See No. 41.
72. Three tracks, probably of Arachnichnus dehiscens.
73. Row of six tracks of Exocampe ornata, and one unknown tridactyle impression.
74. Row of six tracks of Exocampe ornata (?).
75. Row of five tracks of an Exocampe (?).
76. Three double rows of Acanthichnus cursorius. Also numerous marks of a coniferous plant and seeds.
77. Obscure trackway of Acanthichnus cursorius.
78. Four tracks—one front foot—of Xiphopeza triplex. North bank, below Turner's Falls.
79. Row of six tracks of Arachnichnus (?).

80. Two trackways of Acanthichnus cursorius. Supplement, p. 14, Plate VI., fig. 1.
81. One track of Apatichnus circumagens, and one of Brontozoum Sillimanium.
82. One track of Brontozoum Sillimanium.
83. Six tracks of Arachnichnus dehiscens (?), and shrinkage cracks.

Number of tracks on this Table, 853.

Table No. 48.

1. Very nice slab of reddish sandstone, 10° 9′ × 2° 4′, showing four rows (forty-six tracks,) of Anomœpus intermedius, and four of A. gracillimus, probably the typical specimen of A. intermedius, showing impressions of all four feet and the tail. Figured in Supplement, Plate XV., fig. 1., and Plate I., fig. 1. See also page 3. Shows also numerous trails of Unisulcus minutus. From the Ferry at Turner's Falls. 46 impressions in all.

Wall No. 49, *(in Appleton Lecture Room.)*

1. Micaceous sandstone, 10° 8′ × 5° 9′, with eleven tracks of Brontozoum validum, B. exsertum, B. Sillimanium, and numerous trails of Unisulcus intermedius or U. minutus. 1862. Turner's Falls, south side.

2. Micaceous sandstone, 5° 9′ × 3° 9′, with twenty-seven impressions of the same species of Brontozoum as No. 1; Grallator parallelus, with at least one hundred trails of Unisulcus intermedius, and U. minutus, with one of U. Marshi. 1862. Horse Race, Gill.

Total number of tracks on this Wall, 150.

Wall No. 50.

On the north wall of the Ichnological Cabinet, at the east end, near the stairs.

1. Red sandstone, 10° 7′ × 4° 10′, showing no less than 207 different impressions of feet, and eighteen caudal trails. They are chiefly of Anomœpus minor; a few of A. intermedius probably; some of A. minimus, A. gracillimus, Brontozoum Sillimanium, B. validum, Grallator cuneatus, and Chimæra Barratti. Both feet appear of the quadrupeds. Perhaps a few impressions of rain-drops and Anisopus. A remarkable slab, and one requiring careful study. From Howland's farm at Turner's Falls. 1862.

2. Red sandstone, 7° × 2° 5′, counterpart to No. 1, and showing seventy-two tracks of feet in relief, and nine tail traces. They are of Anomœpus minor, A. intermedius, A. gracillimus, Brontozoum Sillimanium, and Chimæra Barratti.

3. Same stone, 4° 4′ × 3°, counterpart to No. 1, and showing twenty-five tracks and ten tail traces. Tracks of Anomœpus minor, A. gracillimus, B. Sillimanium, and others probably.

Total number of tracks and trails on this Wall, 341.

The remainder of the slabs are in the first side-room, and were obtained in 1863, mostly from Roswell Field.

Wall No. 51.

1. Slab of tough sandstone, 3° 2′ × 2° 6′, with thirty-four impressions of Anomœpus intermedius, Brontozoum Sillimanium, Grallator cuneatus, and Plesiornis quadrupes, besides numerous trails of Unisulcus intermedius. Ferry, above Turner's Falls.

2. Slab of sandstone, same as No. 1, with eighty-four impressions of Anomœpus minor, A. intermedius, Brontozoum Sillimanium, Grallator cursorius, G. cuneatus, and Plesiornis quadrupes, besides trails of Unisulcus intermedius.

3. Reddish sandstone, $2° 6' \times 2° 1'$, with tracks of Anomœpus minor, A. intermedius, A. curvatus, Plesiornis quadrupes, and a row of five tracks of A. gracillimus. Ferry at Turner's Falls.

4. Red shale, $1° 8' \times 1° 7'$, with two impressions of Brontozoum exsertum, one of B. validum, a row of two tracks of B. Sillimanium, and trails of Unisulcus minutus. Field's Orchard, Gill.

5. Sandstone, $2° \times 1° 3'$, with eight impressions of Anomœpus intermedius, etc., and trails of Unisulcus intermedius. Ferry, above Turner's Falls.

6. Red shale, $1° 5' \times 1° 6'$, with impressions of Brontozoum validum, B. exsertum, Grallator parallelus, and numerous fine rain-marks. Field's Orchard, Gill.

7. Red shale, $2° 3' \times 1° 9'$, with impressions of Brontozoum validum, B. exsertum, B. Sillimanium, three of Grallator cursorius and numerous fine rain-marks. Field's Orchard, Gill.

8. Red shale, $2° 7' \times 2° 6'$, with thirteen impressions of Brontozoum Sillimanium, Grallator cuneatus, and Tridentipes elegans, and perhaps others. Lily Pond, Turner's Falls.

9. Slab of tough sandstone, in three pieces, $9° 9' \times 4° 5'$, counterparts of Nos. 1 and 2, with tracks in relief of Anomœpus minor, A. intermedius; also tail and claw marks; Brontozoum Sillimanium, Grallator cuneatus, G. cursorius, and trails of Unisulcus intermedius. Ferry, above Turner's Falls.

10. Red sandstone, $2° 9' \times 1° 9'$, with row of eleven impressions of the feet, and a caudal trail of Selenichnus breviusculus, and rain-marks. Some of the latter interesting, as they show lines where the drops run together and trickled down a slope. Ferry.

11. Single track in relief, of Brontozoum giganteum. Turner's Falls.

12. Red sandstone, $2° \times 10'$, with fine impressions of rain-drops. Ferry, above Turner's Falls.

13. Red sandstone, $2° 8' \times 2° 2'$, with six tracks in relief of Anomœpus minor. Ferry.

14. Red sandstone in two pieces, $3° 6' \times 3°$, with tracks in relief of Anomœpus intermedius, Plesiornis quadrupes, Platypterna (?), Brontozoum exsertum, and Grallator cursorius; thirty-five in all. Ferry, above Turner's Falls.

15. Red sandstone, $3° 3' \times 3°$, covered with relief markings of Ænigmichnus multiformis. Ferry.

16. Shale, $4° \times 3°$, with impressions of Plesiornis mirabilis, the type of the species. Three rows of Anisopus gracilis, and tracks of Brontozoum Sillimanium. Supplement, p. 35, Plate XX. Lily Pond, Turner's Falls.

17. Red shale, $5° \times 3° 4'$, with impressions of Anticheiropus hamatus, the type of the species; Brontozoum Sillimanium, Tarsodactylus caudatus, Tridentipes elegantior. Supplement, p. 10, Plate IX., figs. 1, 2. Lily Pond, Turner's Falls.

18. Shale, $2° 9' \times 10°$, with a beautiful row of twenty tracks in relief, of both feet of Arachnichnus dehiscens. Supplement, Plate XVII., fig. 2. Lily Pond, Turner's Falls.

19. Red sandstone, $1° 6' \times 7'$, with a row of eight tracks in relief, and tail trace of Plectropterna gracilis. Supplement, Plate XVII., fig. 1.

Total number of tracks on this Wall, 2,508.

Wall No. 52.

1. Large slab of shale, $5° \times 2°$, with thirty-three impressions of Tridentipes uncus, Brontozoum divaricatum, Anisopus Deweyanus, Platypterna varica (?), Gigantitherium minus, and beautiful marks of rain. Turner's Falls. 1854.

2. Red shale, $1° 7' \times 1° 2'$, with one impression of Brontozoum tuberatum, two rows of Saltator bipedatus. Lily Pond.

3. Indurated shale, $1° 6' \times 1° 5'$, with shrinkage cracks, and a row of six impressions of Anisopus Deweyanus. Turner's Falls.

4. Red sandstone, 4° × 2° 6′, with rows of impressions of Anomœpus intermedius, A. minimus, Brontozoum Sillimanium, Grallator parallelus, and Plesiornis quadrupes. Ferry.

5. Same as 4, 5° 3′ × 1° 11′, with rows of impressions of Anomœpus curvatus, A. minimus, and Apatichnus circumagens (?).

6. Red shale, with a row of ten impressions of Xiphopeza triplex, and others, obscure. Lily Pond.

7. Four impressions of the same, 11′ × 10′.

8. The same in relief, partly counterpart of Nos. 6, and 7. Shows also Brontozoum divaricatum, 2° 3′ × 1° 11′.

9. Thin sandstone, 2° 3′ × 1° 11′, showing impressions of rain-drops, and of a quadruped, perhaps a Tarsodactylus. Ferry.

10. Beautiful slab, 4° 3′ × 1° 9′, showing a row of five impressions of hind feet of Anomœpus curvatus, and trails of Unisulcus intermedius. Type of species of the first. Supplement, Plate XV., fig. 2. Lily Pond, Turner's Falls.

11. Red shale, 2° 6′ × 8′, with trails of Bisulcus undulatus, and Halysichnus laqueatus. Turner's Falls.

12. Same, 1° 8′ × 12′, with trails of Trisulcus laqueatus (type of species,) and Lunula obscura (type of species.) Supplement, Plate III., fig. 4.

13. Micaceous sandstone, 2° 10′ × 12′, with five impressions of hind feet of Anomœpus curvatus, and several of Anisopus gracilis. Lily Pond.

14. Same, 2° 6′ × 1° 3′, with typical impressions of Acanthichnus trilinearis, trails of Trisulcus laqueatus, Lunula obscura, and four impressions of hind feet of Anomœpus curvatus.

15. Red sandstone, 3° × 1° 6′, with the impressions of Brontozoum minusculum. Ferry.

16. Sandstone, 14′ × 11′, with two impressions of hind feet of Anomœpus curvatus. Ferry.

17. Shale, 18′ × 12′, with one impression of Brontozoum minusculum, and one of B. approximatum. Horse Race.

18. Red sandstone, 15′ × 12′, with single impression of B. minusculum. Ferry. Nos. 15, 18, and $\frac{56}{2}$, from the same row.

19. Shale, 13′ × 11′, with impressions of B. divaricatum. Turner's Falls.

20. Red shale, 3° 3′ × 1° 4′, with impressions of B. Sillimanium, Grallator cuneatus, and others. Lily Pond.

Total number of tracks on this Wall, 200.

WALL NO. 53, *(north side.)*

1. Red shale, 3° × 2° 8′, with rows of impressions of Brontozoum Sillimanium, Apatichnus circumagens, Hyphepus Fieldi, and Anisopus gracilis. Field's Orchard, Gill.

2. Red shale, 3° 6′ × 2° 6′, with numerous impressions of B. validum, a few of B. Sillimanium, and many trails of Unisulcus minutus. Field's Orchard, Gill.

3. Gray shale, 19′ × 16′, with impression of B. giganteum. Turner's Falls.

4. Shale, 18′ × 14′, with impression of B. approximatum. Turner's Falls.

5. Slab of sandstone, 2° 10′ × 2° 8′, with impressions above, of Anomœpus intermedius and A. curvatus. In relief of Argozoum pari-digitatum. Field's Orchard, Gill.

6. Sandstone, 19′ × 18′, with single impression of B. giganteum. Turner's Falls.

7. Slab of shale, 4° × 3° 5′, with three rows of impressions of hind feet of Anomœpus curvatus. Counterpart of No. $\frac{3}{8}$. Lily Pond.

8. Gray shale, 24′ × 18′, with single impression of B. giganteum. Turner's Falls.

9. Red sandstone, 18′ × 15′, with one impression of B. approximatum. Ferry, above Turner's Falls.

10. Red sandstone, 4° 6′ × 3° 6′, with rows of impressions of Anomœpus intermedius, and Apatichnus circumagens (?), and single track of B. Sillimanium. Ferry.

11. Gray shale, 20′ × 19′, with single impression of Brontozoum giganteum. Turner's Falls.

12. Shale, 3° 4′ × 2° 3′, with single impression of B. giganteum, double row of Tarsodactylus caudatus, and others, chiefly of Tridentipes elegans. Lily Pond.

Total number of tracks on this Wall, 149.

Wall No. 54, *(east side.)*

1. Red shale, 5° × 4° 3′, with numerous impressions of B. validum, and trails of Unisulcus minutus, with one of Grallator parallelus. Field's Orchard, Gill.

2. Red sandstone, 3° 4′ × 1° 6′, with numerous impressions of Argozoum pari-digitatum, and a few of Sphærapus larvalis. Field's Orchard, Gill.

3. Same rock, in two pieces, 4° 6′ × 1° 7′, with numerous tracks in relief, of A. pari-digitatum.

4. Same as No. 3, 3° × 2°.

5. Red shale, 2° 6′ × 1° 6′, with three impressions of Brontozoum exsertum, and one of Grallator parallelus. Turner's Falls.

6. Cast of tracks of Cheirotherium Barthii. Hildberghausen, Saxony.

7. Same, with shrinkage cracks.

8. Red sandstone, 2° 9′ × 1° 3′, with fine impressions of Brontozoum validum, B. Sillimanium, Grallator parallelus, G. cursorius, and rain-drops. Field's Orchard, Gill.

9. Shale, 16′ × 15′, with scattered impressions of Anisopus gracilis. Turner's Falls.

10. Gray shale, 2° × 14′, with impression of Brontozoum approximatum, type of species. Turner's Falls.

11. Shale, 1° 9′ × 12′, with impressions of Gigantitherium minus, Hyphepus Fieldi, and Grallator cursorius. Lily Pond.

12. Sandstone, 2° 4′ × 1° 5′, with scattered, deeply impressed print of feet of Anomœpus minor, and Plesiornis quadrupes. Howland's Farm, Gill.

13. Sandstone, 2° 6′ × 1° 6′, with two rows of Anomœpus curvatus, and one of A. intermedius. Ferry.

Total number of tracks on this Wall, 184.

Case No. 55.

The slabs in this Case are too small to require measurements.

1. Two impressions of Harpedactylus gracilior, typical specimen. Supplement, Plate III., fig. 2. North bank, below Turner's Falls.

2. Track of Platypterna, with caudal trail. Supplement, p. 31, Plate XVI., fig. 2. Turner's Falls.

3. Toxichnus inæqualis, typical specimen. North bank, below Turner's Falls. Supplement, Plate V., fig. 5.

4. Exocampe minima, typical specimen. Supplement, Plate XVIII., fig. 3. Field's Orchard, Gill.

5. Comptichnus obesus, row of six impressions, typical specimen. Supplement, Plate XVIII., fig. 6. Lily Pond.

6. Single impression of Brontozoum minusculum. Lily Pond.

7. Climacodichnus corrugatus, several trails, type of species. Ferry.

8. Six impressions of Xiphopeza triplex, and Arachnichnus dehiscens. Field's Orchard, Gill.

9. Brontozoum validum. Lily Pond.

10. Macropterna (?). Lily Pond.
11. Anomœpus. Field's Orchard, Gill.
12. Four impressions of both feet of Anisopus gracilis. Lily Pond.
13. Xiphopeza triplex. North bank, below the dam.
14. Argozoum dispari-digitatum. Turner's Falls.
15. Five trails of Acanthichnus. Lily Pond.
16. Brontozoum Sillimanium (?). Turner's Falls.
17. Trails of Cochlichnus anguineus. Lily Pond.
18. Grallator cursorius. Lily Pond.
19. Row of impressions of Anisopus gracilis, and numerous trails of Unisulcus intermedius. Lily Pond.
20. Trail of Halysichnus laqueatus. Lily Pond.
21. Three tracks in relief, of Anomœpus minimus—both feet—and one of Plectropterna minitans. Field's Orchard, Gill.
22. Twelve impressions of both feet of Exocampe ornata. Turner's Falls, north bank, below the dam.
23. Two tracks in relief, of Plectropterna lineans. Lily Pond.
24. Five tracks in relief, in a row, of Shepardia palmipes. Lily Pond.
25. Row of impressions of Orthodactylus intro-vergens, and another of Anisopus gracilis. Lily Pond.
26. Tracks in relief, of Exocampe ornata. North bank, below the dam.
27. Impressions of Plectropterna lineans. Lily Pond.
28. Impressions of Plectropterna angusta. Lily Pond.
29. Impressions of Brontozoum exsertum. Lily Pond.
30. Row of twelve tracks in relief of Arachnichnus dehiscens. Lily Pond.
31. Three tracks in relief of Orthodactylus intro-vergens. Lily Pond.
32. Seven impressions in a row, of Arachnichnus dehiscens. Lily Pond.
33. Ten impressions in a row of Toxichnus inæqualis. Typical specimen. Howland's Farm, Turner's Falls. Supplement, Plate V., fig. 6.
34. Impressions of rain-drops. Turner's Falls.
35. Two impressions of Anomœpus curvatus. Turner's Falls.
36. Grammepus erismatus. Lily Pond.
37. Part of impression of Grallator cursorius. Turner's Falls.
38. Row of eight tracks in relief, of Macropterna gracilipes. Lily Pond.
39. Counterparts, showing single impression of Brontozoum validum. Field's Orchard, Gill.
40. Single track in relief, of Orthodactylus intro-vergens. Turner's Falls.
41. Single impression of Comptichnus obesus. Lily Pond.
42. Two trackways of Acanthichnus cursorius, one of Copeza propinquata, and one uncertain. Lily Pond.
43. Copeza propinquata. Lily Pond.
44. Bifurculipes laqueatus, and Conopsoides curtus. Lily Pond.
45. Hexapodichnus magnus. Lily Pond.
46. Impressions of feet of Apatichnus circumagens. Lily Pond.
47. Impressions of both feet of Tarsodactylus caudatus. Lily Pond.
48. Acanthichnus saltatorius. Lily Pond.
49. Harpepus capillaris. Lily Pond.
50. Acanthichnus anguineus, type of species. Lily Pond. Supplement, Plate VII., fig. 4.
51. Acanthichnus cursorius. Lily Pond.
52. Bifurculipes laqueatus. Lily Pond.

53. Conopsoides curtus, typical specimen. Supplement, Plate XVIII., fig. 4.
54. Copeza propinquata, and a plant. Supplement, Plate XVIII., fig. 2. Lily Pond.
55. Two trackways of Bifurculipes laqueatus. Lily Pond.
56, 82, 97. Bifurculipes elachistotatus. Lily Pond.
57, 67, 80. Conopsoides larvalis. Lily Pond.
58, 74, 88, 96, 102. Bifurculipes laqueatus. Lily Pond.
59. Acanthichnus alternans, typical specimen. Lily Pond. Supplement, Plate VI., fig. 5.
60, 81, 89, 104. Acanthichnus cursorius. Lily Pond.
61, 77, 79, 93, 95. Bifurculipes. Lily Pond.
62, 65, 66, 90, 91. Bifurculipes curvatus. Lily Pond.
62. Cochlea Archimedea. Lily Pond.
63. Copeza propinquata. Lily Pond.
68, 75. Acanthichnus saltatorius. Lily Pond.
69. Acanthichnus, Copeza cruscularis, and Conopsoides curtus. Lily Pond.
70. Bifurculipes elachistotatus, and Conopsoides curtus. Lily Pond.
71, 85. Copeza. Lily Pond.
72. Sagittarius alternans. Lily Pond.
73, 78. Copeza cruscularis. Lily Pond.
76. Bisulcus undulatus. Lily Pond.
83. Acanthichnus. Lily Pond.
84. Acanthichnus and Copeza. Lily Pond.
86. Acanthichnus cursorius, and Bifurculipes laqueatus. Lily Pond.
87. A. cursorius and unknown quadrupeds. Lily Pond.
92. Two trackways of Conopsoides curtus, and one of Bifurculipes elachistotatus. Lily Pond.
94. Two rows of Sagittarius alternans. Supplement, Plate XVIII., fig. 5. Lily Pond.
98. Bifurculipes curvatus, and B. elachistotatus. Lily Pond.
99. Acanthichnus, and two trackways of Harpepus capillaris. Lily Pond.
100. Perhaps the veins of a leaf. Lily Pond.
103. Unknown insect track. Lily Pond.
105. Copeza propinquata, and new species of Cochlichnus. Lily Pond.
106. Brontozoum validum. Lily Pond.
107. Row of four impressions of Anisopus gracilis. Lily Pond.
108. Plectropterna, both feet in relief. North bank, below Turner's Falls.
109. Two tracks in relief, of Xiphopeza triplex. Same as 108.
110. Grallator parallelus. Lily Pond.
111. Row of six tracks in relief, of Arachnichnus dehiscens. Lily Pond.
112. Five tracks in relief, of Anomœpus minimus, type of species, and two of A. intermedius. Field's Orchard, Gill. Supplement, Plate II., figs. 1, 2.
113. Row of Acanthichnus rectilinearis. Typical specimen. Also Bifurculipes elachistotatus.

Total number of tracks in this Case, 3,700.

Table No. 56.

1. Shale, 12′ × 11′, with two beautiful impressions of Brontozoum minusculum, and B. Sillimanium, showing the markings of the skin on the feet. Supplement, Plate XVI., fig. 1. Lily Pond.

2. Red sandstone, 1° 5′ × 12′, with two fine impressions of B. minusculum, and B. Sillimanium. Ferry.

Total number of tracks on this Table, 4.

TABLE No. 57.

1. Shale, 1° 10′ × 1° 4′, in two pieces with hinges, showing foot of Tridentipes ingens. Horse Race, Gill.

2. Shale, from same locality, 2° × 1° 4′, in two pieces with hinge, showing foot of Brontozoum giganteum.

TABLE No. 58.

1. Hard shale, a little below the layer upon which the animals trod, 12° 6′ × 3°, showing a row of four impressions, and one isolated track of Brontozoum divaricatum, five of B. validum, and six of B. Sillimanium—two in the same row—besides a few others indistinct, say 20 in all.

WALL No. 59, *(large room, over Nos. 35 and 36.)*

1 to 6. Casts of Protichnites from Potsdam sandstone of Canada. Beauharnois.

7, 8. Casts of Climatichnites Wilsoni, Logan. From Perth, C. W.

Nos. 1 to 8, presented in 1864, by Sir W. E. Logan, to Dr. Hitchcock.

Total number of Tracks in the Hitchcock Ichnological Cabinet, . . . 21,773

APPENDIX. [C.]

Exocampe minima.—On page 11 a notice of this beautiful species is given, without detailed description. I have recently obtained from Mr. Field a larger slab than those of this species in the Cabinet, containing two or three rows of the impressions made by this animal; and present the following description, based partly on this specimen and partly upon No. $\frac{55}{4}$.

Hind Foot.—Digitigrade; tetradactylous; toes curved outward gracefully; length, reckoning outward, 0.125, 0.25, 0.325, 0.175, so far as they impressed the mud in walking. Divarication of the outer toes from 100° to 130°; the angle between the third and fourth being greater than that between any other two. Divergence of the axis of the foot from the median line outward, 16° to 50°. Distance of the heel from the median line, 0.2 to 0.45. Length of the step from track to track of the same foot, 1.1 to 2 inches. Width of the toes, less than the twentieth of an inch. Very delicate claws occasionally seen. Width of the trackway, 1.5 inches. Some of the impressions display a heel similar to that of E. arcta, in Plate XXV., fig. 6, of Ichnology.

Fore Foot.—Digitigrade, but less so than the hind foot; pentedactylous; one short hind toe, and the four front ones about equally distributed through an arc of 138°, and varying in length from 0.15 to 0.2 inch. Toes nearly straight, slightly curved outward. Axis of the foot but little turned outward from the median line. Fore foot generally situated a little outside of the hind one in walking, not more than a tenth of an inch apart.

This animal differs from E. ornata by its smaller stature, the greater width of its trackway, and the greater irregularity of the arrangement of its footsteps in walking. It must have been, though smaller, a more clumsy or unwieldy animal.

Locality.—It has been found as yet only at Field's Orchard, in Gill.

C. H. H.

Fig. 1. (

Fig. 2. (
Fig. 3. T
Figs. 4 an

Fig. 1. F
Fig. 2. C
Fig. 3. F
Fig. 4. F
Fig. 5. S
Fig. 6. C
Fig. 7. C

Fig. 1. C
Fig. 2. C
Fig. 3. I
Fig. 4. T
Fig. 5. T

Fig. 1. C

Fig. 1. C

Fig. 2. C
Fig. 3. C
Fig. 4. B
Fig. 5. C
Fig. 6. C

DESCRIPTION OF THE PLATES.

Plate I.

Fig. 1. Outline of the tracks of Anomœpus intermedius, of the natural size. From slab No. $\frac{48}{1}$.

Fig. 2. Outline track of the hind foot of Anomœpus curvatus, natural size.

Fig. 3. Tracks of Anisopus gracilior, natural size. From slab No. $\frac{46}{3}$.

Figs. 4 and 5. Impressions of the natural size, referred to Ænigmichnus multiformis.

Plate II.

Fig. 1. Fore foot of Anomœpus minimus, part of Fig. 2.

Fig. 2. Outline of slab containing five tracks of A. minimus, natural size. From slab No. $\frac{55}{112}$.

Fig. 3. Feet of Trihamus elegans, natural size.

Fig. 4. Feet of Arachnichnus dehiscens, natural size.

Fig. 5. Same as Fig. 4, with shrinkage cracks.

Fig. 6. Outline of impressions of Lunula obscura, natural size.

Fig. 7. Outline of hind foot of Selenichnus falcatus (?), natural size. No. $\frac{47}{67}$.

Plate III.

Fig. 1. Outline tracks of Harpedactylus crassus, natural size.

Fig. 2. Outline tracks of Harpedactylus gracilior, natural size. From slab No. $\frac{55}{1}$.

Fig. 3. Impressions of Grammichnus alpha, natural size.

Fig. 4. Trail of Trisulcus laqueatus, natural size. From slab No. $\frac{52}{12}$.

Fig. 5. Trail of Bisulcus undulatus, natural size. From slab No. $\frac{10}{6}$.

Plate IV.

Fig. 1. Outline of track of Brontozoum divaricatum, natural size.

Plate V.

Fig. 1. Outline of track of Grallator parallelus, showing all the phalanges and heel bones, natural size.

Fig. 2. Outline of part of a track of Brontozoum Sillimanium, natural size.

Fig. 3. Outline of track of Leptonyx lateralis, natural size. From slab No. $\frac{47}{40}$.

Fig. 4. Row of tracks of Comptichnus obesus, natural size.

Fig. 5. Outline of tracks of Toxichnus inæqualis, natural size. From slab No. $\frac{55}{3}$.

Fig. 6. Outline of foot of Toxichnus, natural size. From slab No. $\frac{55}{33}$.

Plate VI.

Fig. 1. Tracks of Acanthichnus cursorius, natural size. From slab No. $\frac{47}{80}$.
Fig. 2. Tracks of Acanthichnus rectilinearis, natural size.
Fig. 3. Tracks of Sagittarius alternans, natural size.
Fig. 4. Tracks of Conopsoides curtus, natural size.
Fig. 5. Tracks of Acanthichnus alternans, natural size. From slab No. $\frac{55}{59}$.
Fig. 6. Tracks of Acanthichnus alatus, natural size.
Fig. 7. Tracks of Acanthichnus cursorius, natural size.
Fig. 8. Tracks of Acanthichnus cursorius, natural size.
Fig. 9. Tracks of Acanthichnus saltatorius, natural size.
Fig. 10. Tracks of Acanthichnus divaricatus, natural size.
Fig. 11. Tracks of Acanthichnus trilinearis, natural size. From slab No. $\frac{52}{14}$.
Fig. 12. Tracks of Acanthichnus saltatorius, natural size.
Fig. 13. Tracks of Acanthichnus punctatus, natural size.
Fig. 14. Tracks of Copeza punctata, natural size.
Fig. 15. Tracks of Copeza punctata, natural size.
Fig. 16. Tracks of Ampelichnus sulcatus, natural size.
Fig. 17. Tracks of Copeza (?), natural size.
Fig. 18. Tracks of Acanthichnus cursorius, natural size.

Plate VII.

Fig. 1. Outline of slab of Copeza propinquata, natural size.
Fig. 2. Outline of slab of Bifurculipes curvatus, natural size.
Fig. 3. Outline of slab of Pterichnus centipes, natural size.
Fig. 4. Outline of slab of Acanthichnus anguineus, natural size. From slab No. $\frac{55}{50}$.
Fig. 5. Outline of slab of Climacodichnus corrugatus, natural size.
Fig. 6. Outline of slab of Harpepus capillaris, natural size.
Fig. 7. Outline of slab of Bifurculipes, natural size.
Fig. 8. Outline of slab of Bifurculipes, natural size.
Fig. 9. Outline of slab of Bifurculipes curvatus, natural size.
Fig. 10. Outline of slab showing Copeza propinquata, Acanthichnus cursorius, and Acanthichnus divaricatus, natural size.
Fig. 11. Not labelled by Dr. Hitchcock.

Plate VIII.

Figs. 1 to 7. Tracks of a living crab from Florida—the Ocypode arenaria.

Plate IX.

Fig. 1. Outline track of Anticheiropus hamatus, natural size. From slab No. $\frac{10}{5}$.
Fig. 2. Outline track of Anticheiropus hamatus, natural size.
Fig. 3. Outline track of Anticheiropus pilulatus, natural size.
Figs. 4, 5. Supposed tracks of the Iguanodon, one-ninth of the natural size.
Fig. 6. Sketch of bones of the foot of Megadactylus polyzelus, natural size.
Fig. 7. Outline track of Grallator gracilis, natural size.

Plate X.

Fig. 1. Outline track of Brontozoum giganteum, natural size. From slab No. $\frac{45}{8}$.
Fig. 2. Outline track of Brontozoum approximatum, natural size. From slab No. $\frac{54}{10}$.

Plate XI.

Figs. 1 to 6. Various forms of the tracks of Ænigmichnus multiformis, natural size.

Plate XII.

Figs. 1 to 4. Various forms of the tracks of Ænigmichnus multiformis, natural size.

Plate XIII.

Photograph of Climacodichnus corrugatus, one-third of the natural size.

Plate XIV.

Photograph of Ænigmichnus multiformis, one-twentieth of the natural size. Copied from No. $\frac{27}{21}$.

Plate XV.

Fig. 1. Photograph of a fine slab of Anomœpus intermedius, one sixty-fifth of the natural size. Copied from No. $\frac{48}{1}$.

Fig. 2. Photograph of a fine slab of Anomœpus curvatus, one-thirtieth of the natural size. Copied from No. $\frac{52}{10}$.

Plate XVI.

Fig. 1. Photograph of Brontozoum minusculum and B. Sillimanium, the former showing papillary impressions; one-fourth of the natural size. Copied from No. $\frac{56}{1}$.

Fig. 2. Photograph of Platypterna (?), showing a supposed caudal trail of singular character; of the natural size. Copied from No. $\frac{55}{2}$.

Plate XVII.

Fig. 1. Photograph of fine row of Plectropterna gracilis in relief, one-fourth of the natural size. Copied from No. $\frac{51}{19}$.

Fig. 2. Photograph of fine row of Arachnichnus dehiscens, one-ninth of the natural size. Copied from No. $\frac{51}{18}$.

Plate XVIII.

Fig. 1. Photograph of Copeza punctata, of the natural size. Copied from No. $\frac{36}{45}$.

Fig. 2. Photograph of slab of Copeza propinquata, of the natural size. Copied from No. $\frac{55}{54}$.

Fig. 3. Photograph of slab of Exocampe minima, of the natural size. Copied from No. $\frac{55}{4}$.

Fig. 4. Photograph of slab of Conopsoides curtus, of the natural size. Copied from No. $\frac{55}{53}$.

Fig. 5. Photograph of slab of Sagittarius alternans, of the natural size. Copied from No. $\frac{55}{94}$.

Fig. 6. Photograph of slab of Comptichnus obesus, natural size. Copied from No. $\frac{55}{5}$.

Plate XIX.

Photograph of slab of Anomœpus major, showing curious caudal impressions; one-tenth of the natural size. Copied from No. $\frac{1}{7}$.

Plate XX.

Various impressions, pedal and caudal, of the Plesiornis mirabilis, natural size. From No. $\frac{51}{16}$.

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Ænigmichnus
Ampelichnus
Andrew, John
Anisopus grac
Annelids, trai
Anomœpus cu
Anomœpus gr
Anomœpus int
Anomœpus mi
Anomœpus, p
fo
co
Anticheiropus

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Archæopteryx
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g
i

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Fig. 5.

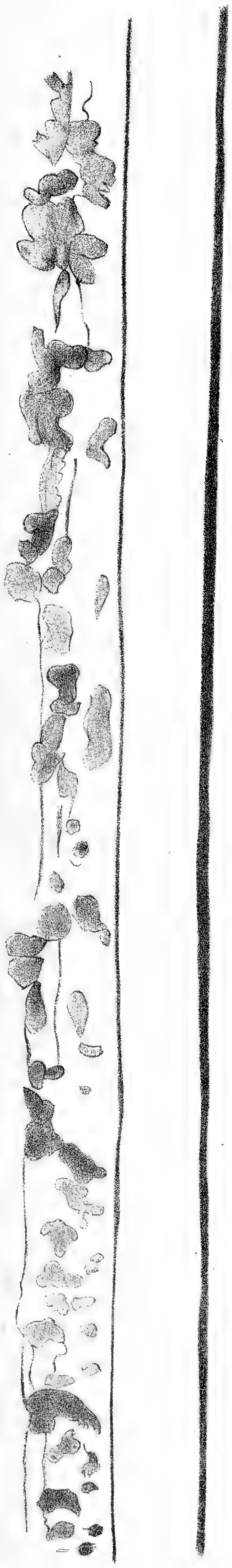
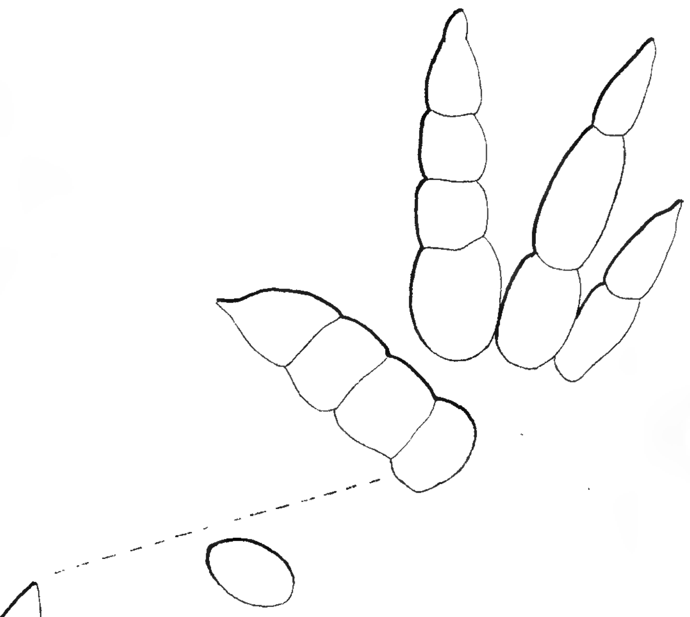


Fig. 4.

Aenigmichnus multiformis.

Fig. 3.

Anisopus gracilior.



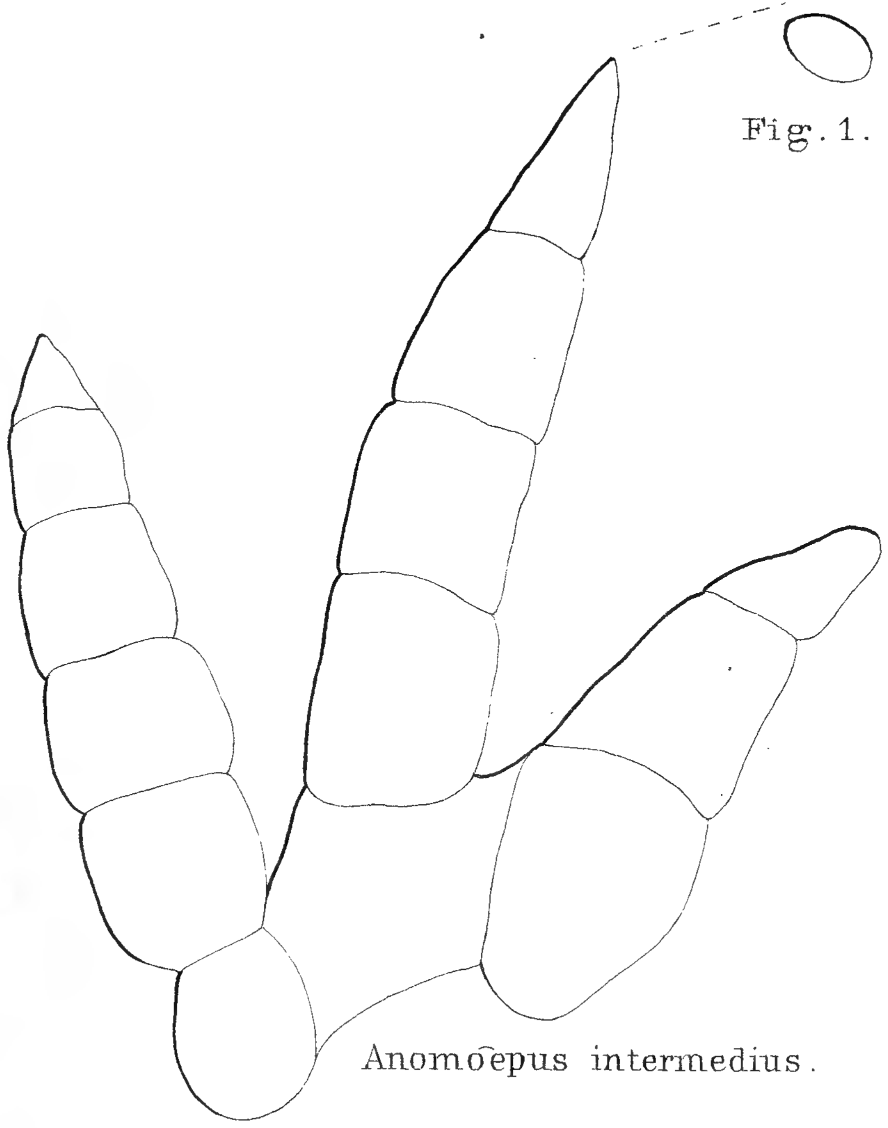
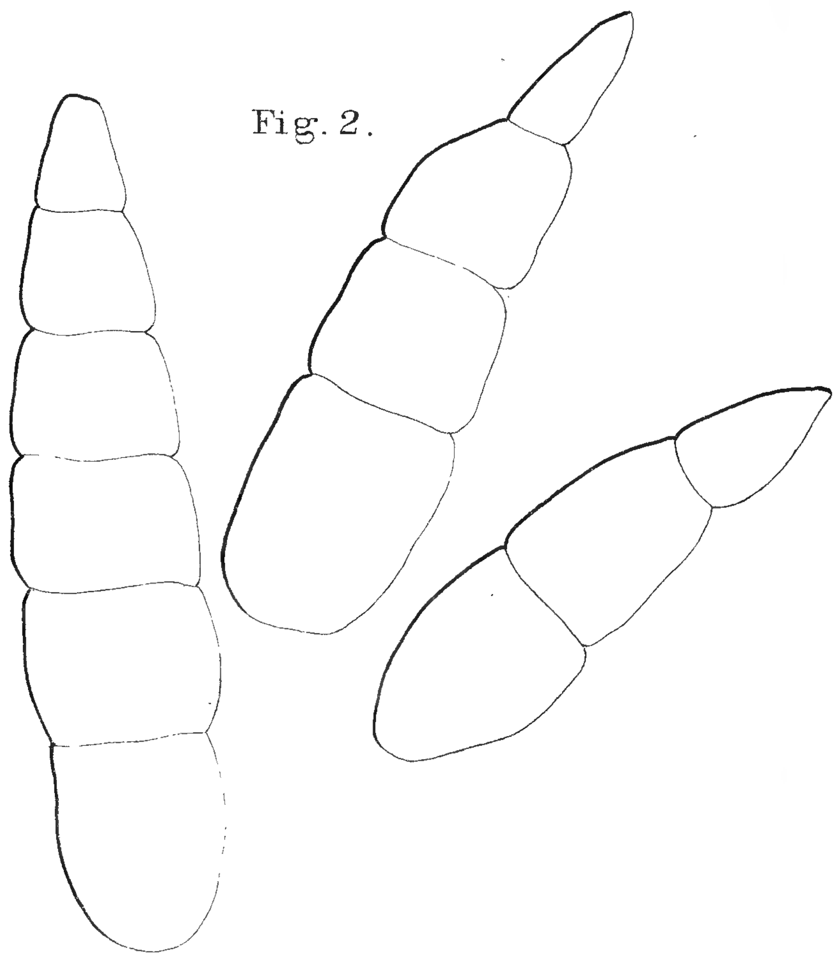


Fig. 1.

Anomoepus intermedius.

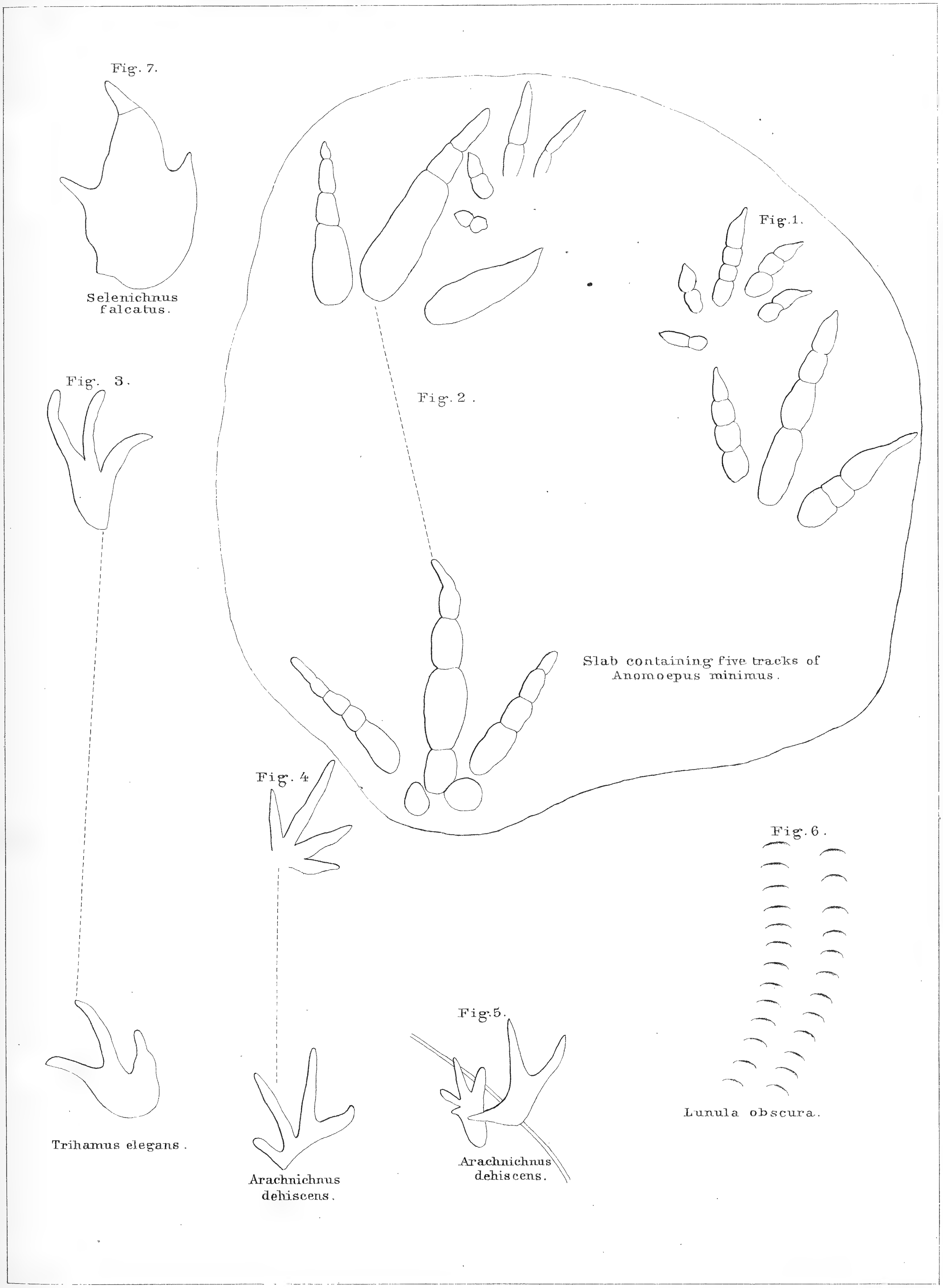
Fig. 2.



Anomoepus curvatus.

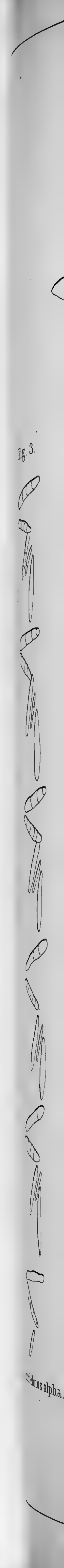
A. Meisel, Lith.

Pl. II.



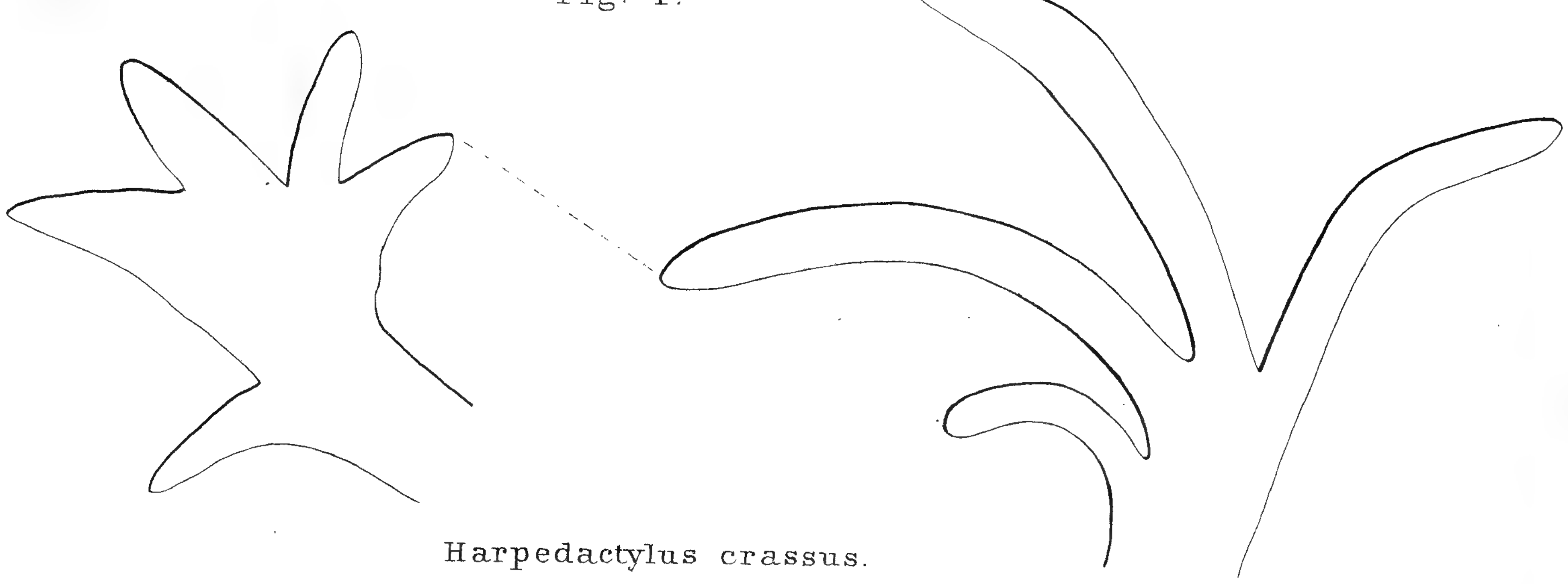
A. Meisel, Lith.

Fig. 3.



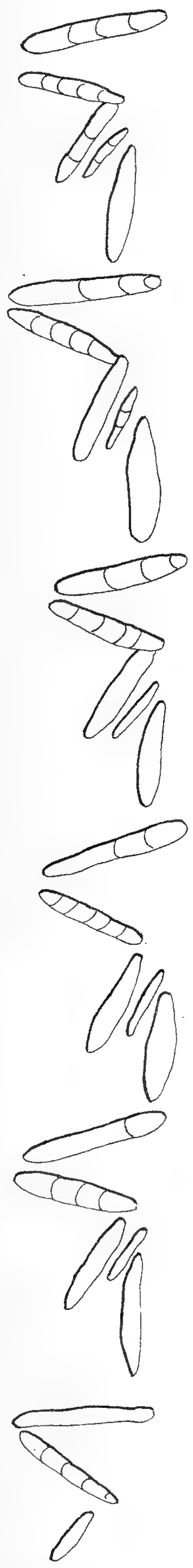
alpha.

Fig. 1.



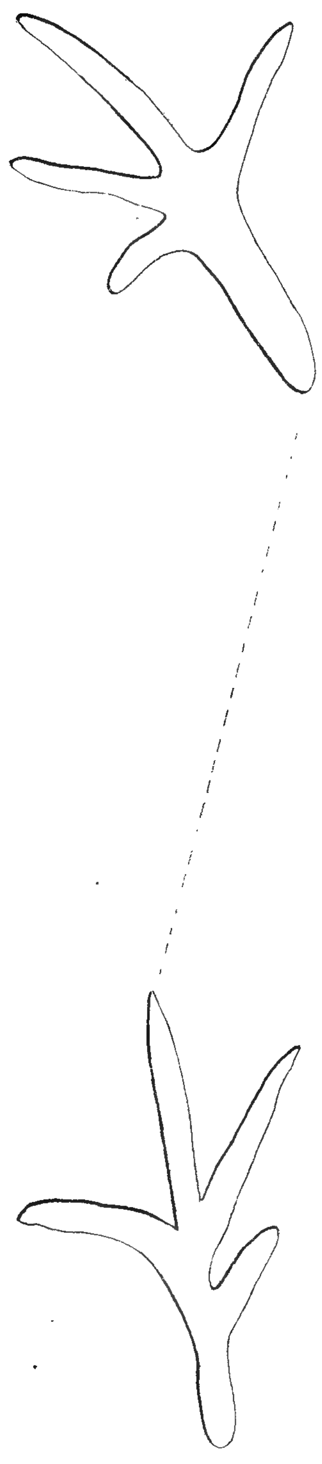
Harpedactylus crassus.

Fig. 3.



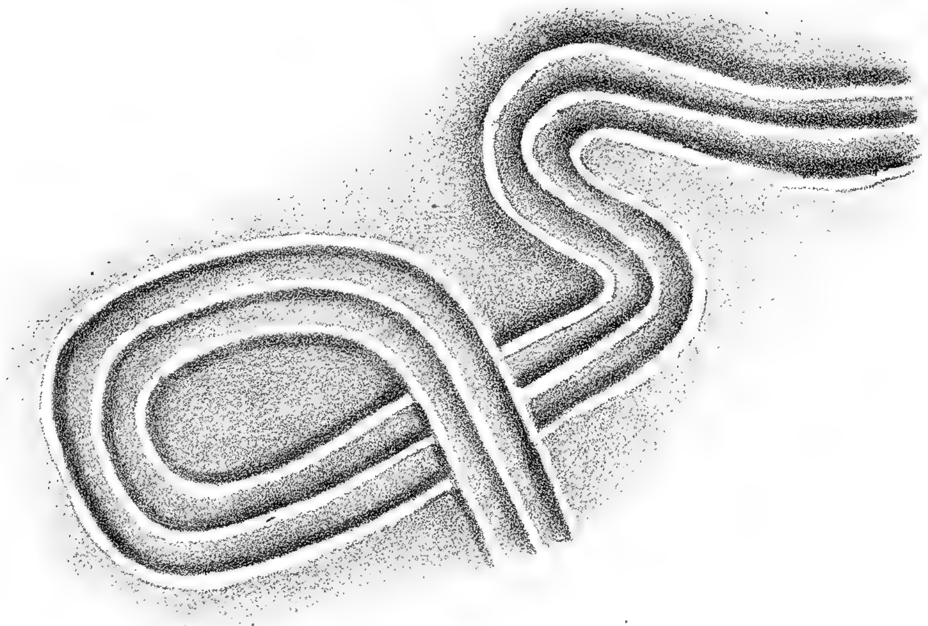
Grammichnus alpha.

Fig. 2.



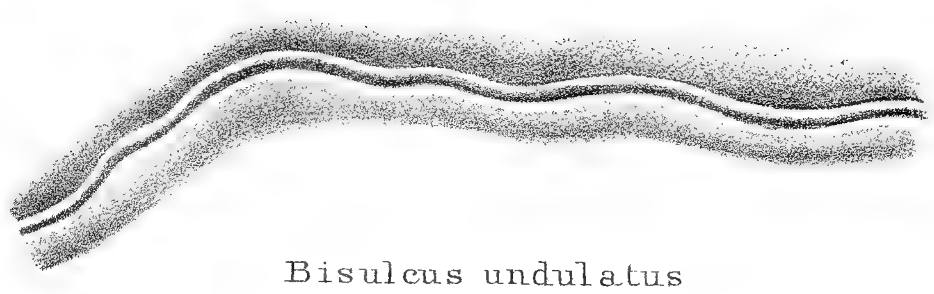
Harpedactylus gracilior.

Fig. 4.



Trisulcus laqueatus.

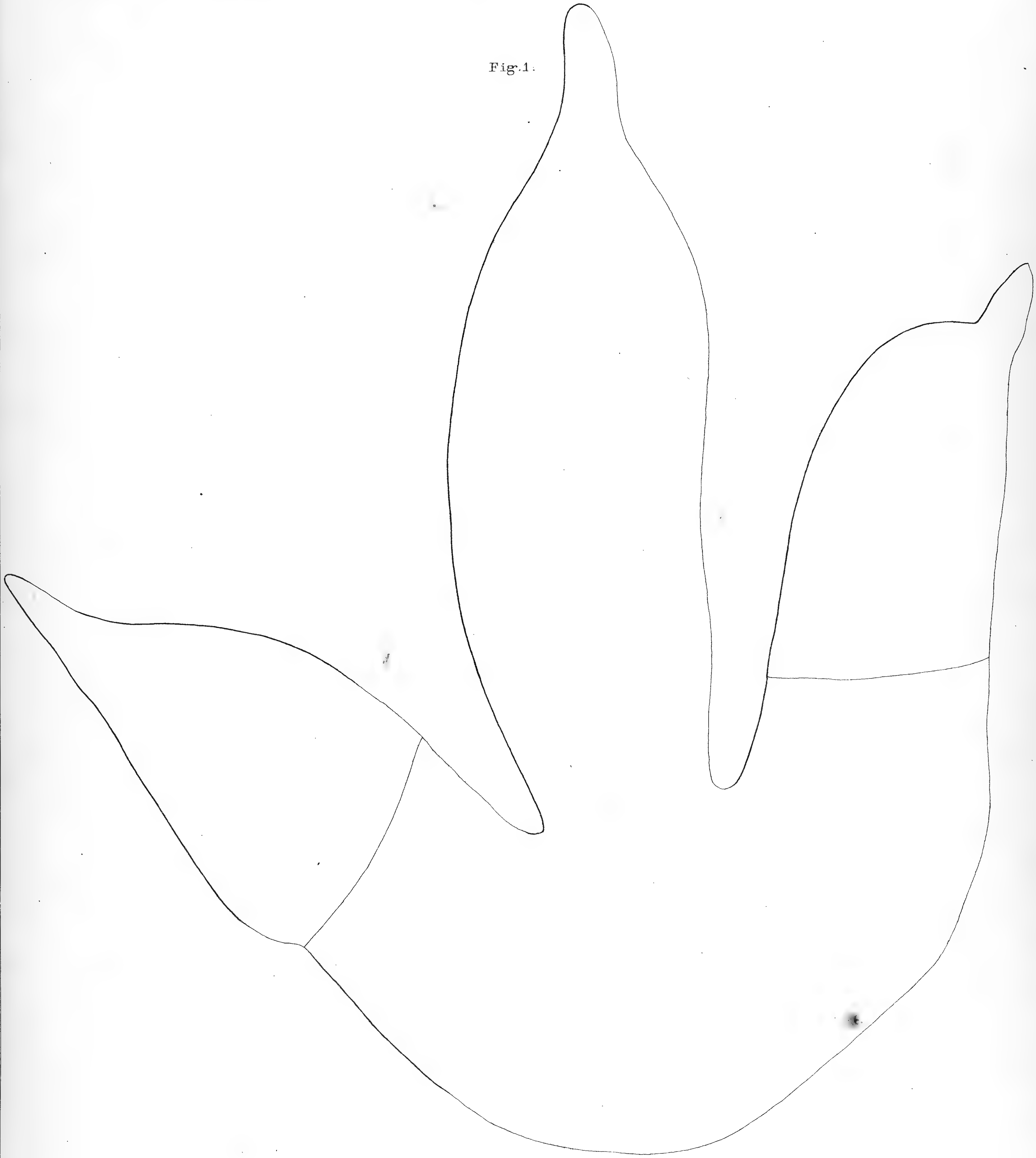
Fig. 5.



Bisulcus undulatus

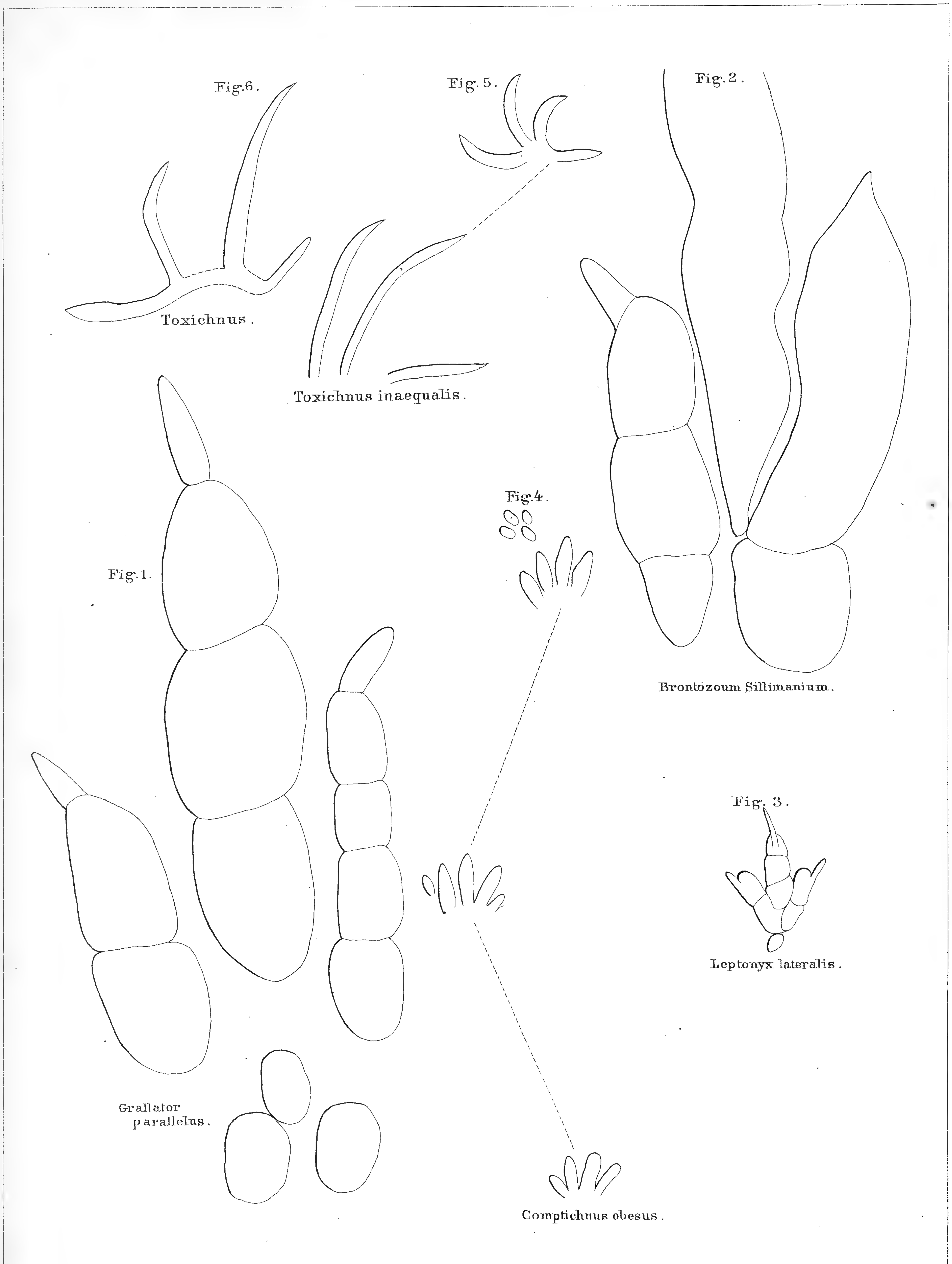
A. Meisel, Lith.

Fig. 1.



Brontozoum divaricatum.

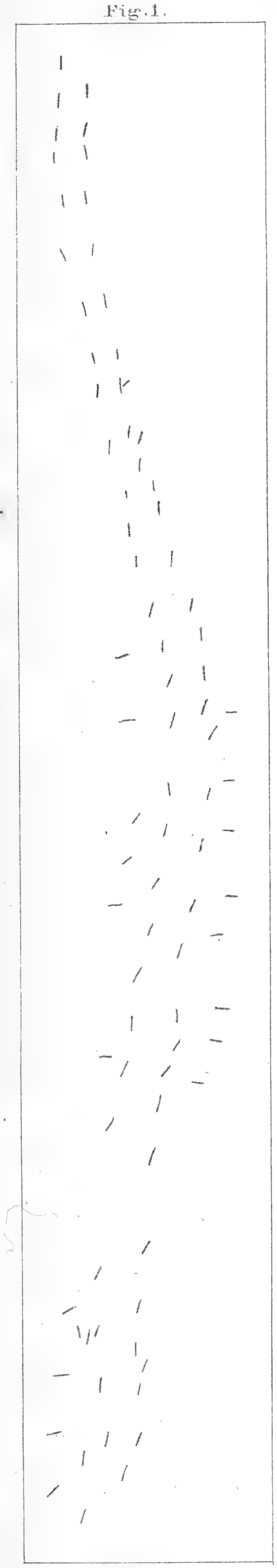
A. Meisel, Lith.



A.Meisel,Lith.

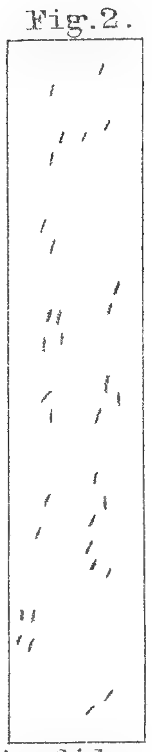

Fig. 1.
Acanthichnus cursorius.

Fig. 1.



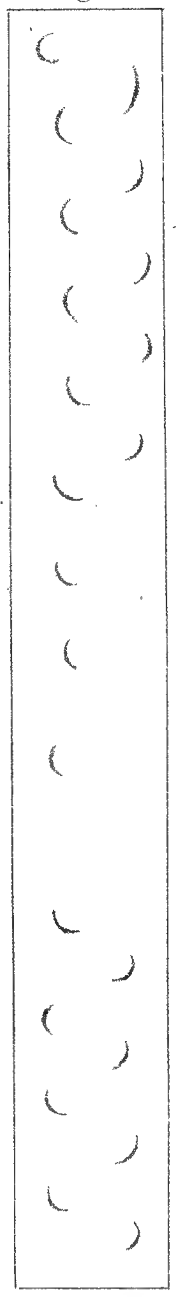
Acanthichnus cursorius.

Fig. 2.



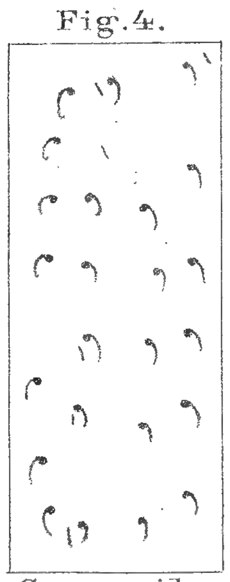
Acanthichnus rectilinearis.

Fig. 3.



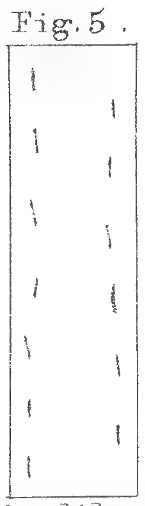
Sagittarius alternans.

Fig. 4.



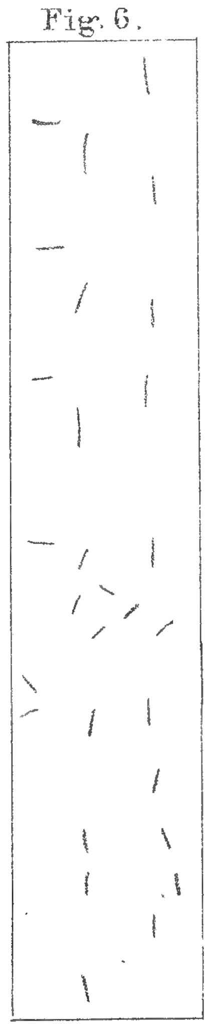
Conopsoides curtus.

Fig. 5.



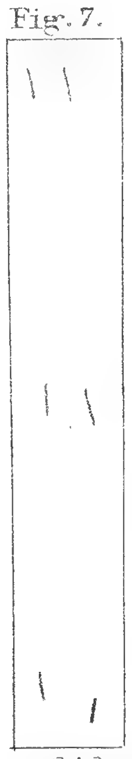
Acanthichnus alternans.

Fig. 6.



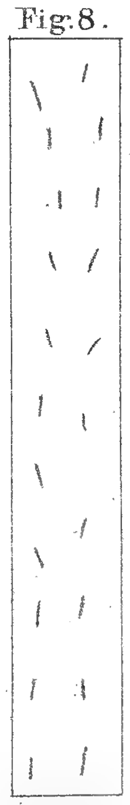
Acanthichnus alatus.

Fig. 7.



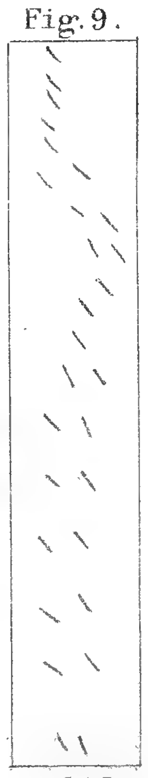
Acanthichnus cursorius.

Fig. 8.



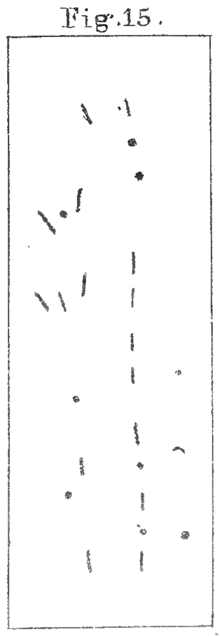
Acanthichnus cursorius.

Fig. 9.



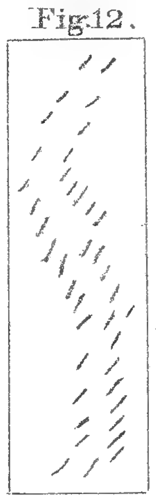
Acanthichnus saltatorius.

Fig. 15.



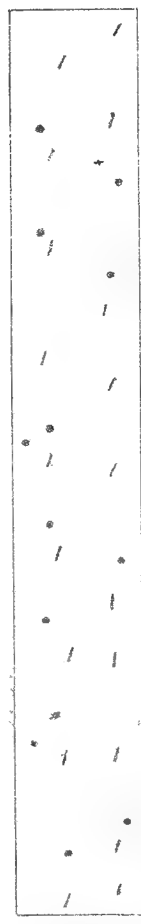
Copeza punctata.

Fig. 12.



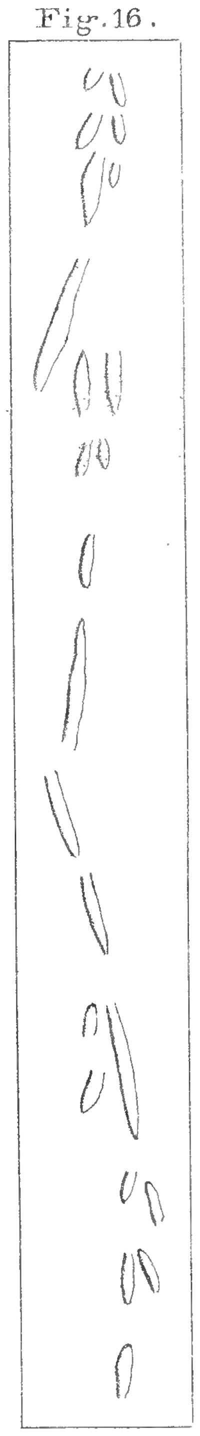
Acanthichnus saltatorius.

Fig. 13.



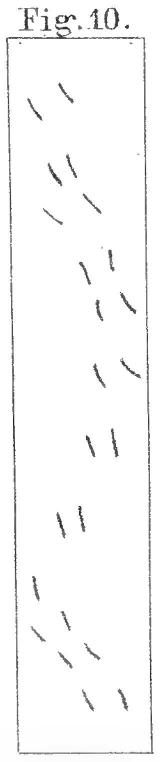
Acanthichnus punctatus.

Fig. 16.



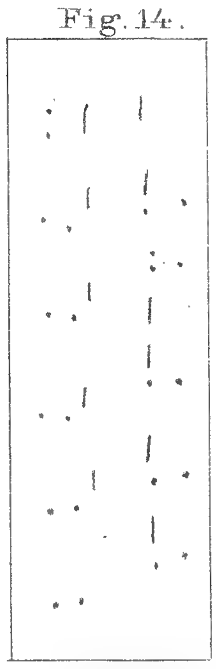
Ampelichnus sulcatus.

Fig. 10.



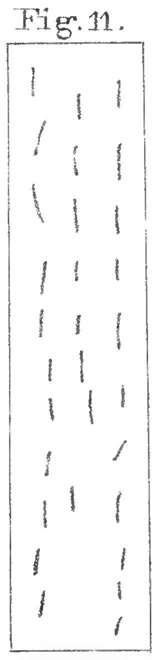
Acanthichnus divaricatus.

Fig. 14.



Copeza punctata.

Fig. 11.



Acanthichnus trilinearis.

Fig. 17.

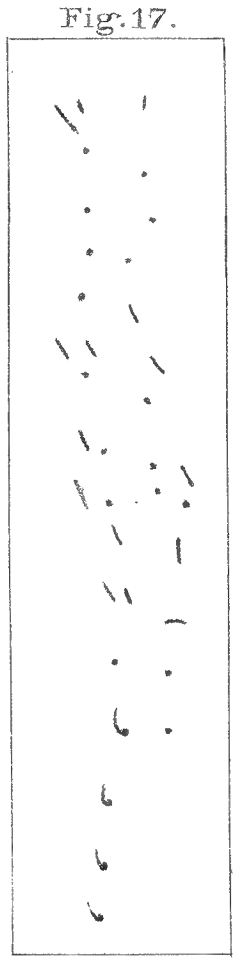
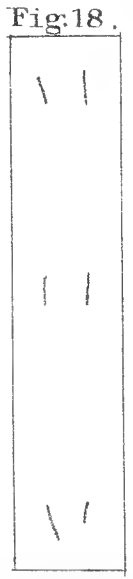
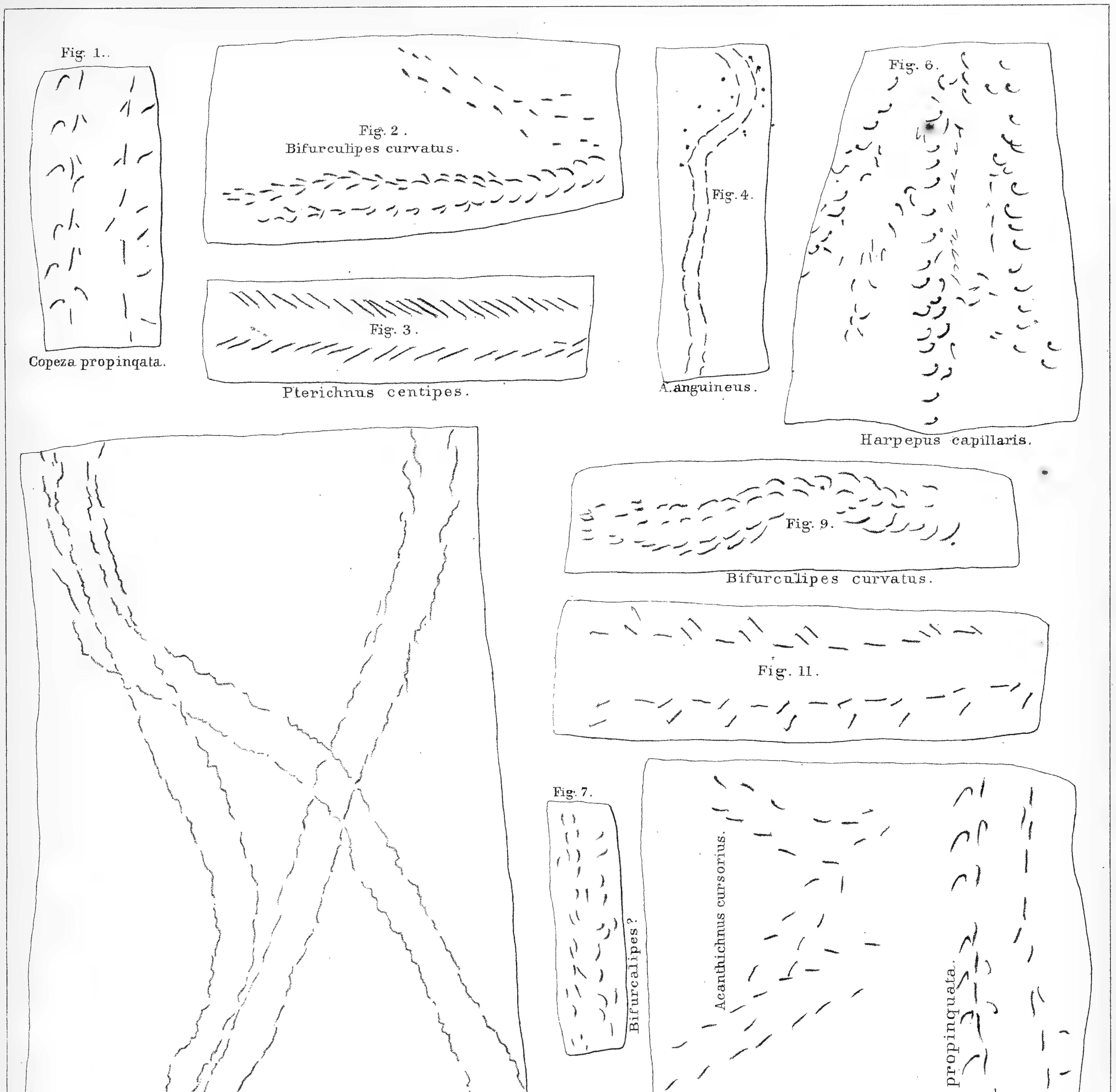


Fig. 18.



Acanthichnus cursorius.

A. Meisel, Lith.



A. Meisel Lith.


Fig.5

Tracks of Ocypode arenaria.

A. Meisel Lith.

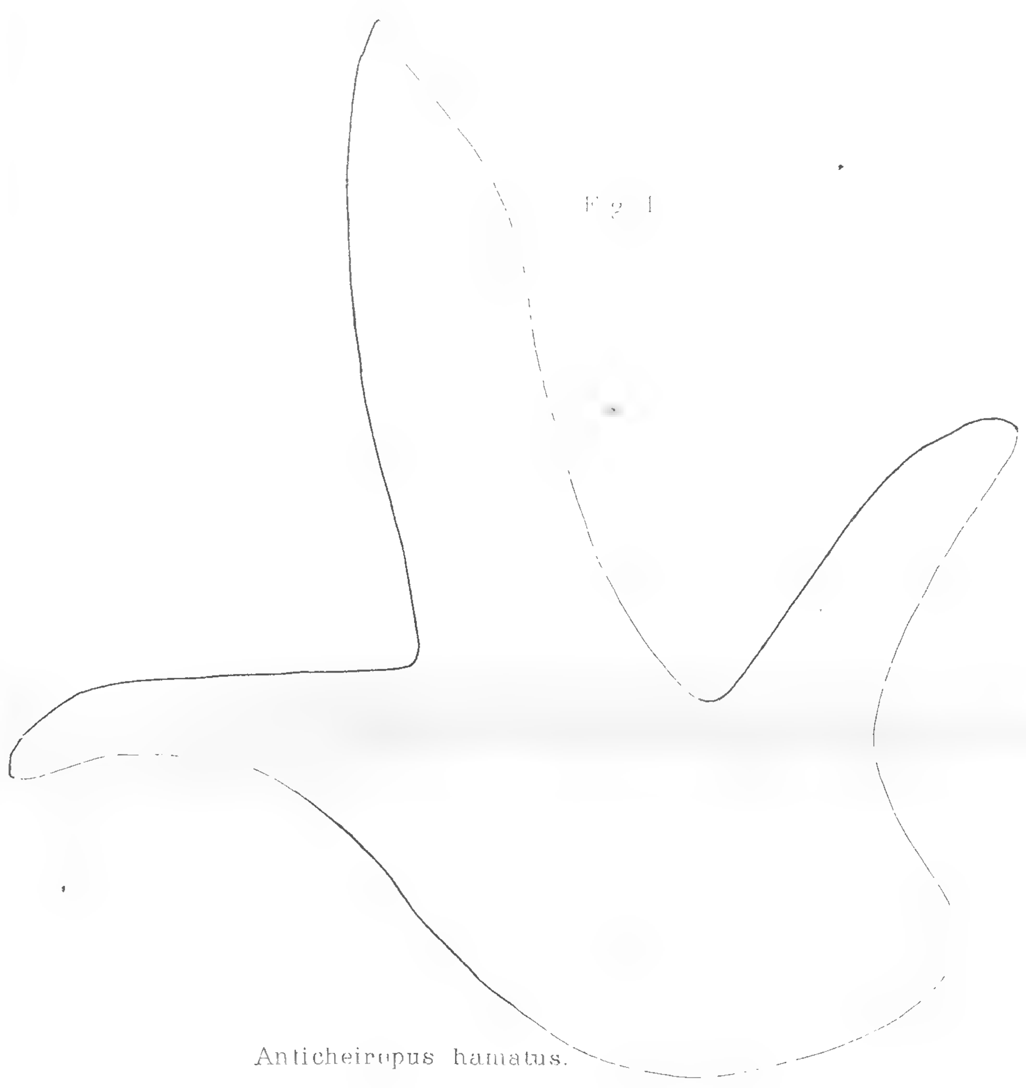


Fig. 1.

Anticheiropus hamatus.

Fig. 6.

Bones of the right foot of Megadactylus polyzelus.

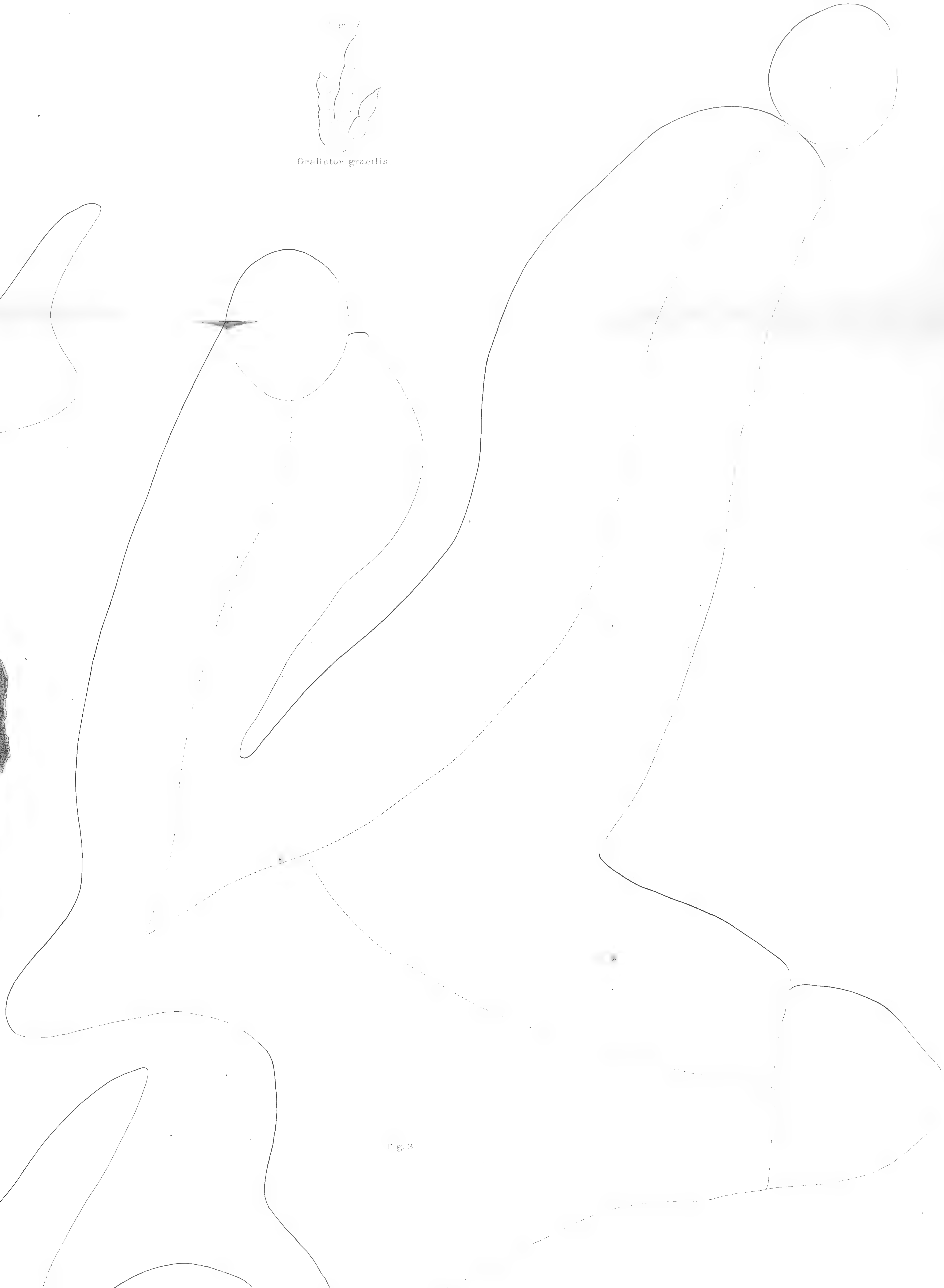


Fig. 7.

Grallator gracilis.

Fig. 3.

Anticheiropus pilulatus.

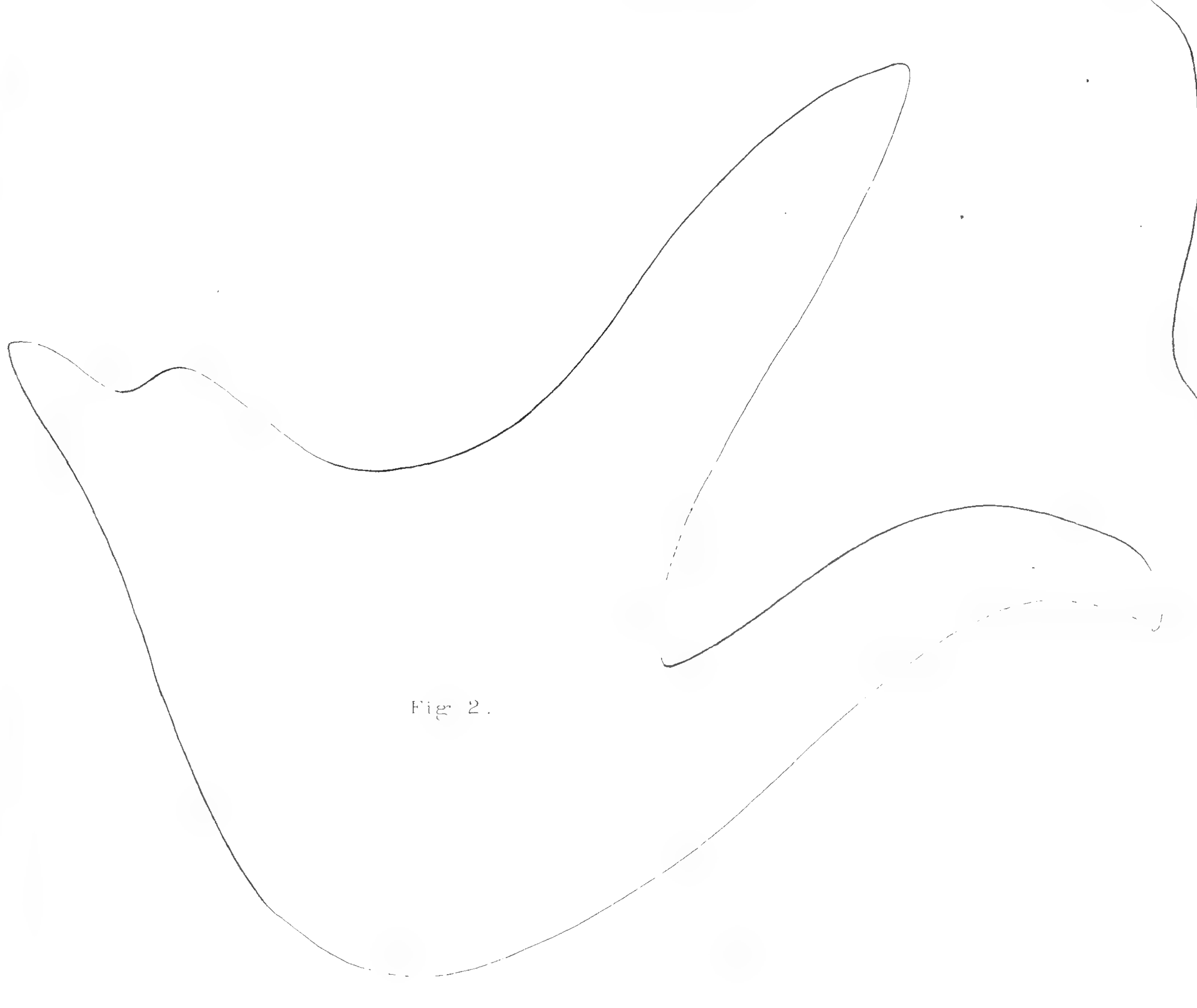


Fig. 2.

Anticheiropus hamatus.

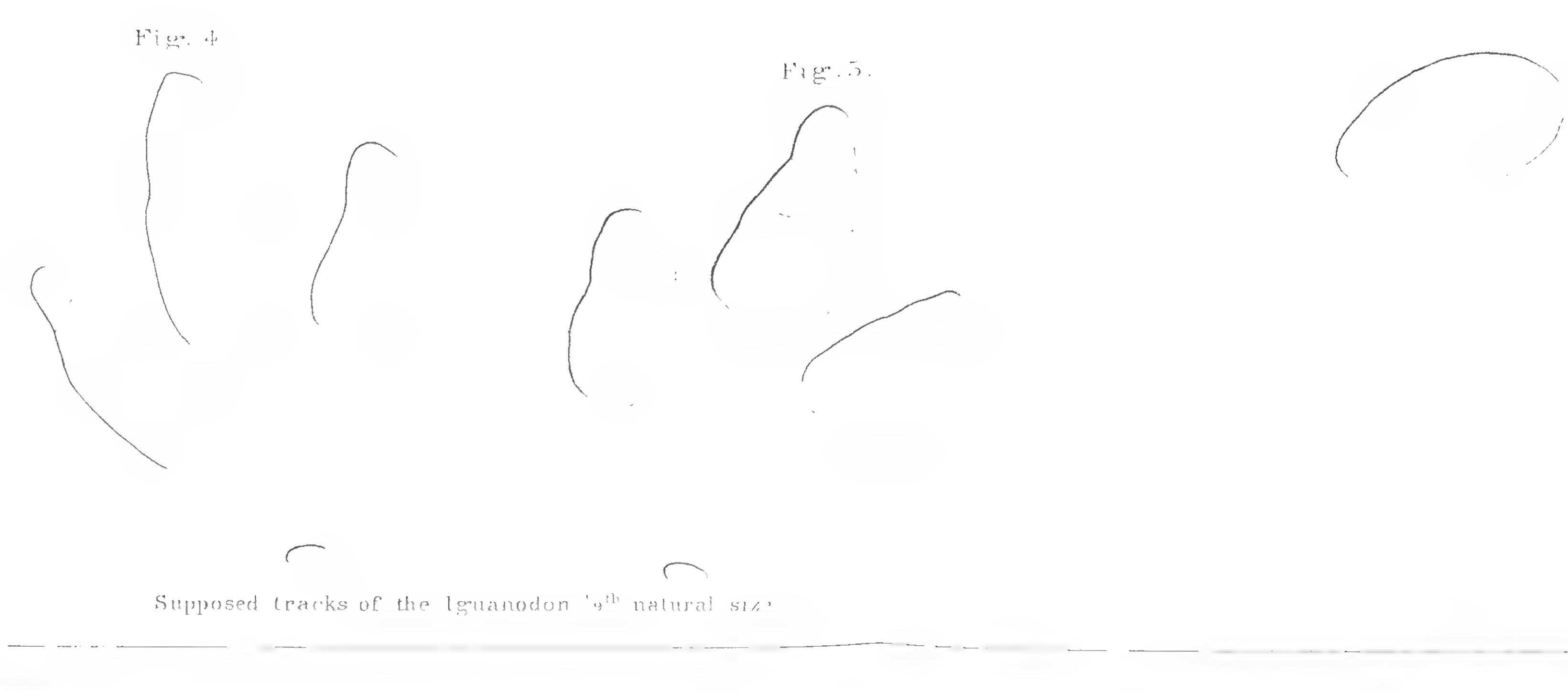


Fig. 4. Fig. 5.

Supposed tracks of the Iguanodon 1/9th natural size

Pl. X

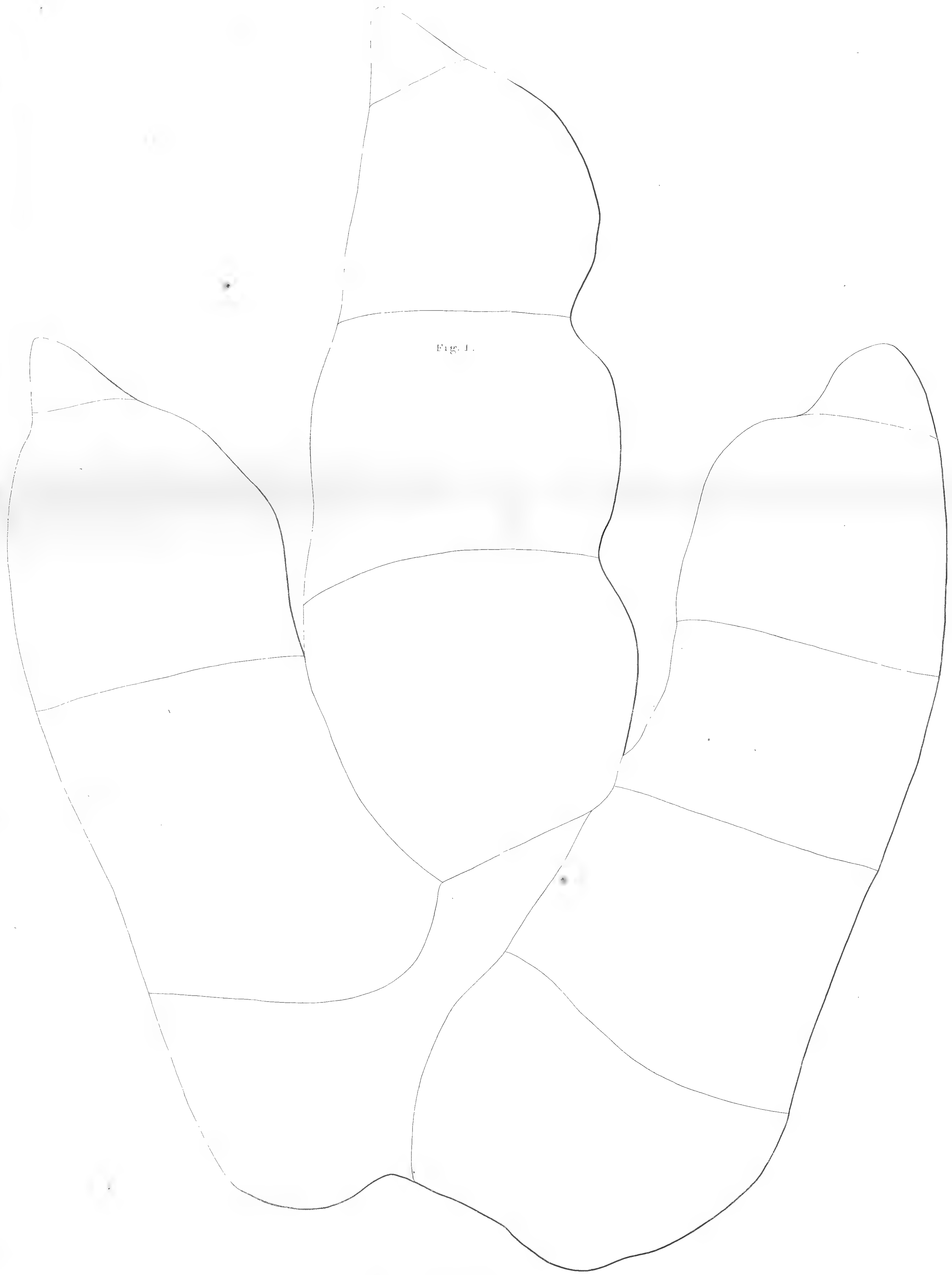


Fig. 1.

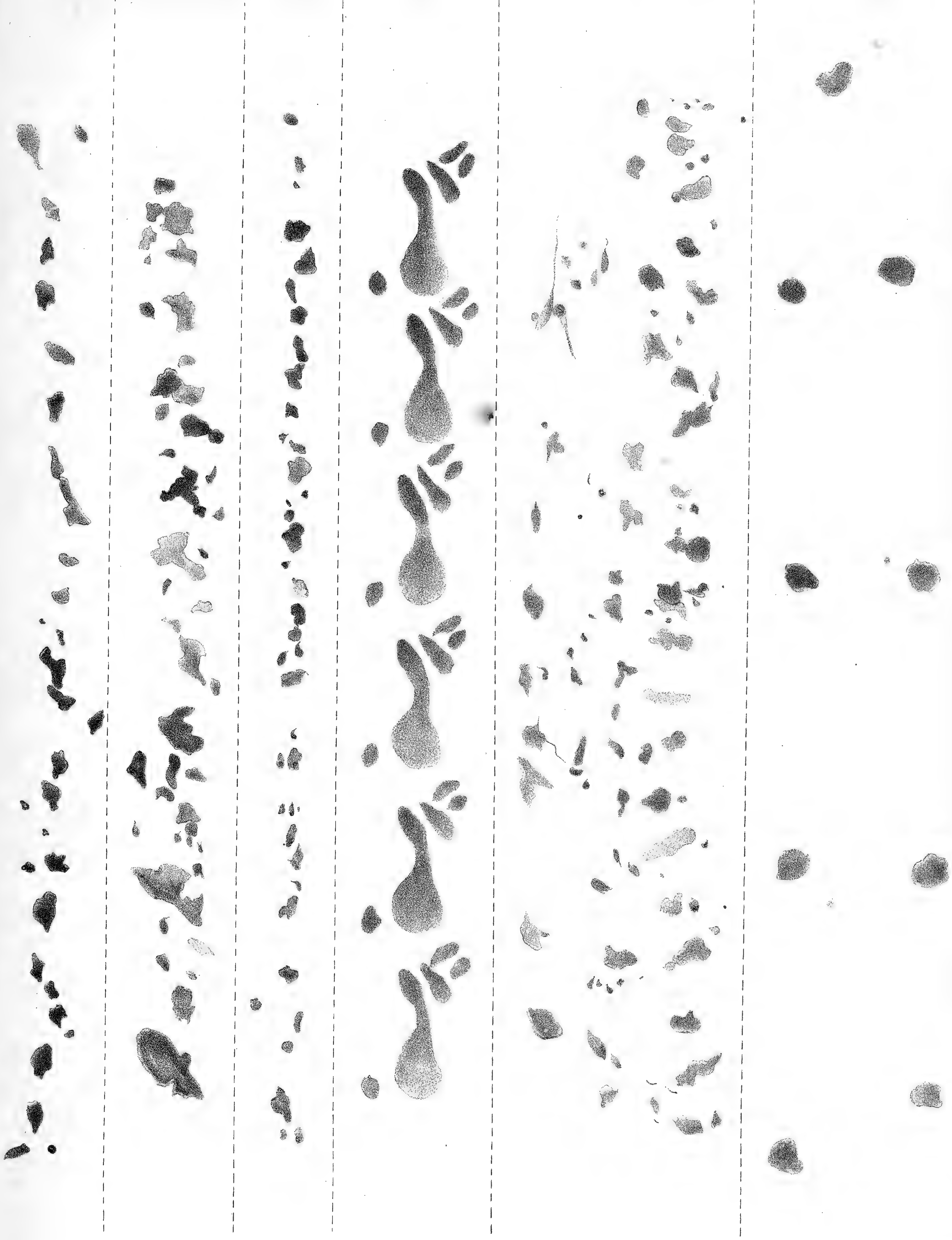
Brontozoum giganteum.

Fig. 2.

Brontozoum approximatum.

A. Meisel, Lith.

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.



A. Meisel Lith.

Pl. XII.

Fig. 1.

Fig. 2.

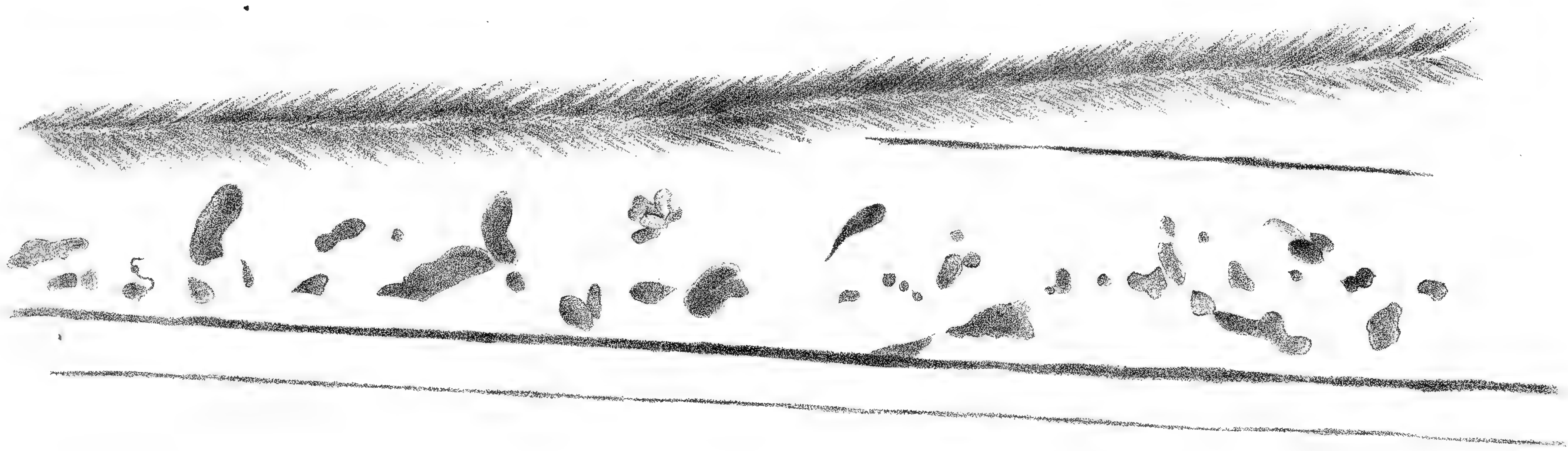
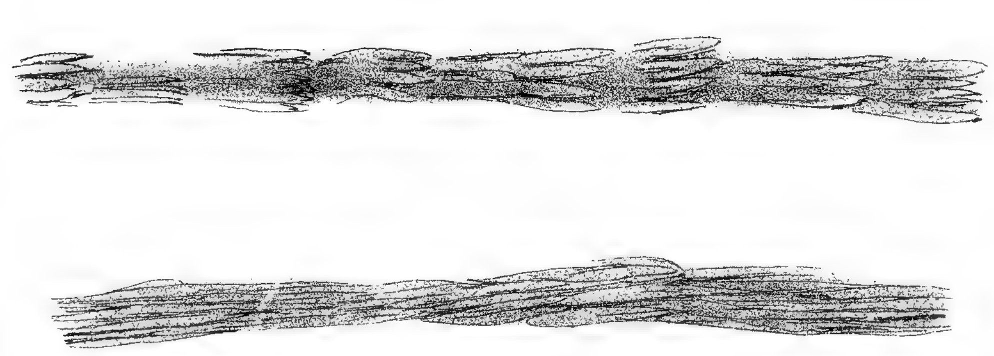


Fig. 3.

Fig. 4.

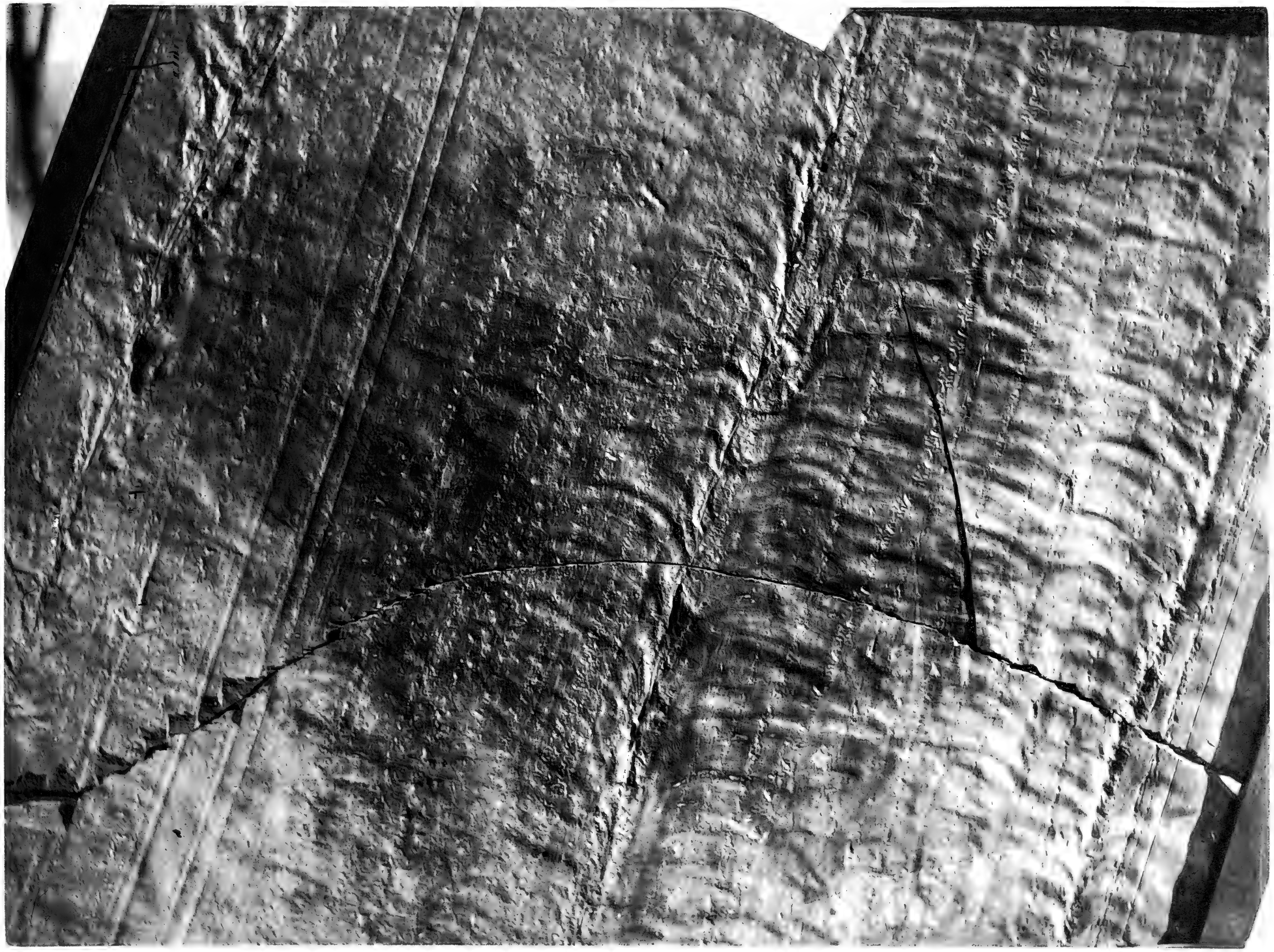


A. Meisel Lith.

Climacodichnus corrugatus.

J. L. LOVELL, Photo.

PLATE XIV



Aenigmichnus multiformis.

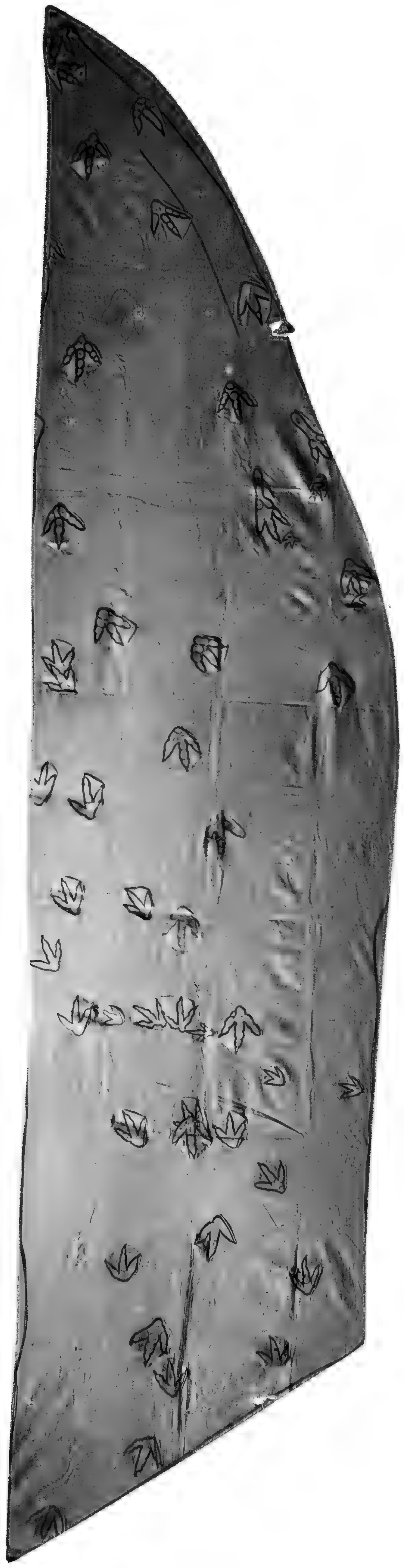
J. L. Lovell, Photo.

PLATE XV.

FIG. 2.

Anomœpus curvatus.

FIG. 1.



Anomœpus intermedius.

J. L. Lovell, Photo.

PLATE XVI.

FIG. 1.

Brontozoum Sillimanium and B. minusculum.

FIG. 2.

Caudal Trail?

J. L. LOVELL, Photo.

FIG. 1.

Plectropterna gracilis.

FIG. 2.

Arachnichnus dehiscens.

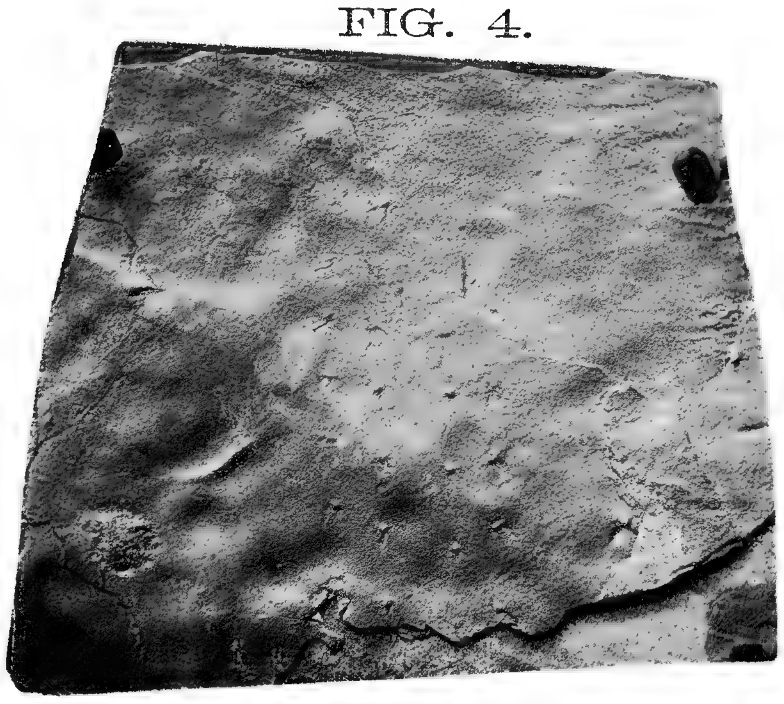
J. L. LOVELL, Photo.

PLATE XVIII.

FIG. 1.

Copeza punctata.

FIG. 4.



Conopsoides curtus.

FIG. 3.

Exocampe minima.

FIG. 6.

Comptichnus obesus.

FIG. 5.

Sagittarius alternans.

FIG. 2.

Copeza propinquata.

J. L. LOVELL, Photo.

Anomœpus major.

J. L. LOVELL, Photo.

Plesiornis mirabilis.

A. Meisel, Lith.